SHOP MANUAL

Unit Rebuilding

CUMMINS

H, HS, HR, HRS, NH, NHS, NHRS DIESEL ENGINES

Bulletin No. 6301-C

CUMMINS ENGINE COMPANY, INC. • COLUMBUS, INDIANA, U.S.A

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FOREWORD

This Shop Manual was written exclusively for the use of Cummins Dealers, Owners of Cummins Engines, and Mechanics who repair and rebuild Cummins H and NH Diesel Engines. The term "H and NH" as used in this manual applies to H, HS, HR, HRS, NH, NHS and NHRS Cummins Diesels. The special detailed information in this manual is being furnished you for three reasons:

1. To acquaint you with the work methods that have proved most economical in rebuilding Cummins engines.

2. To give you reasonable parts replacement worn limits that will help ensure an uninterrupted period of service from your rebuilt engine *without sacrificing the service still available from slightly worn parts.*

3. To provide you with all the technical information necessary for quality rebuilding of these quality built engines.

This is the third major revision of the Shop Manual made since it was first printed in 1947. It reflects many important improvements in engine design and service methods developed during these six years. Your Cummins Dealer has a record of this manual, and he will notify you when the next revision is made so that you can always have the latest information.

December, 1953

CUMMINS ENGINE COMPANY, INC., COLUMBUS, INDIANA. U. S. A.

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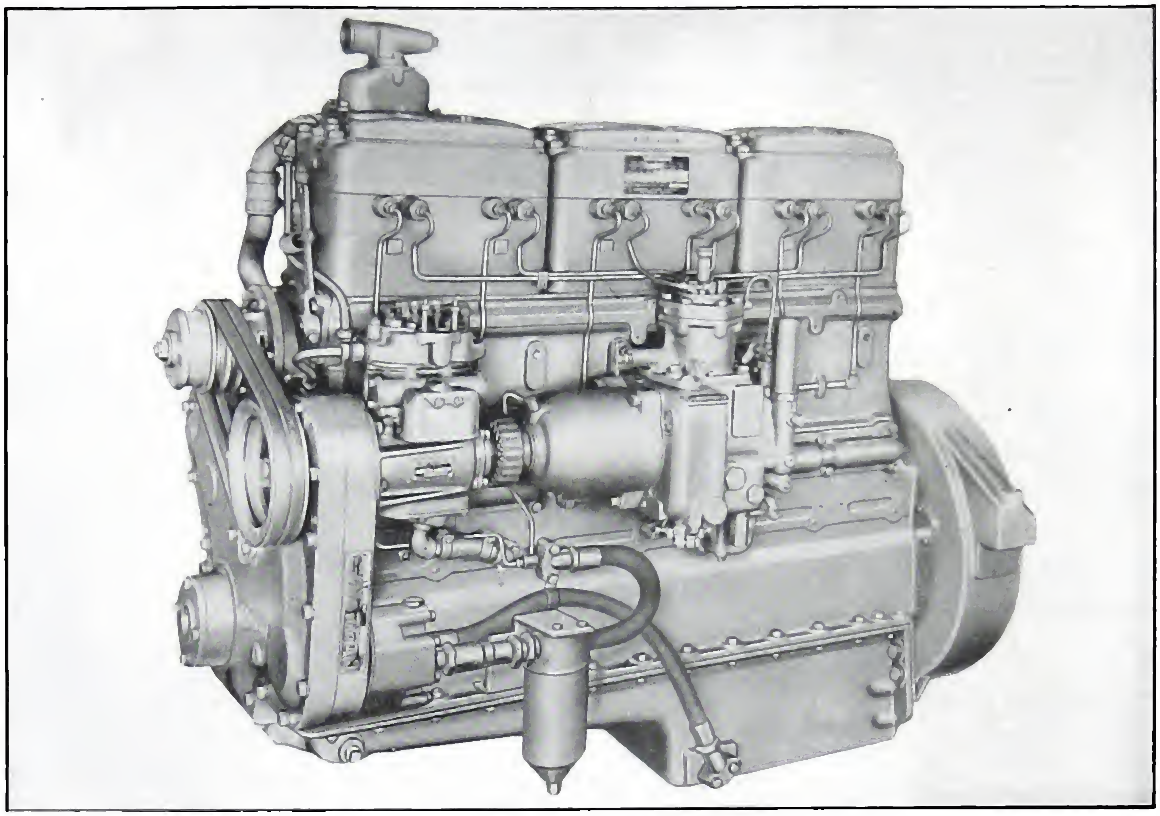


Fig. 1. Model H, 6 cylinder engine, fuel pump side

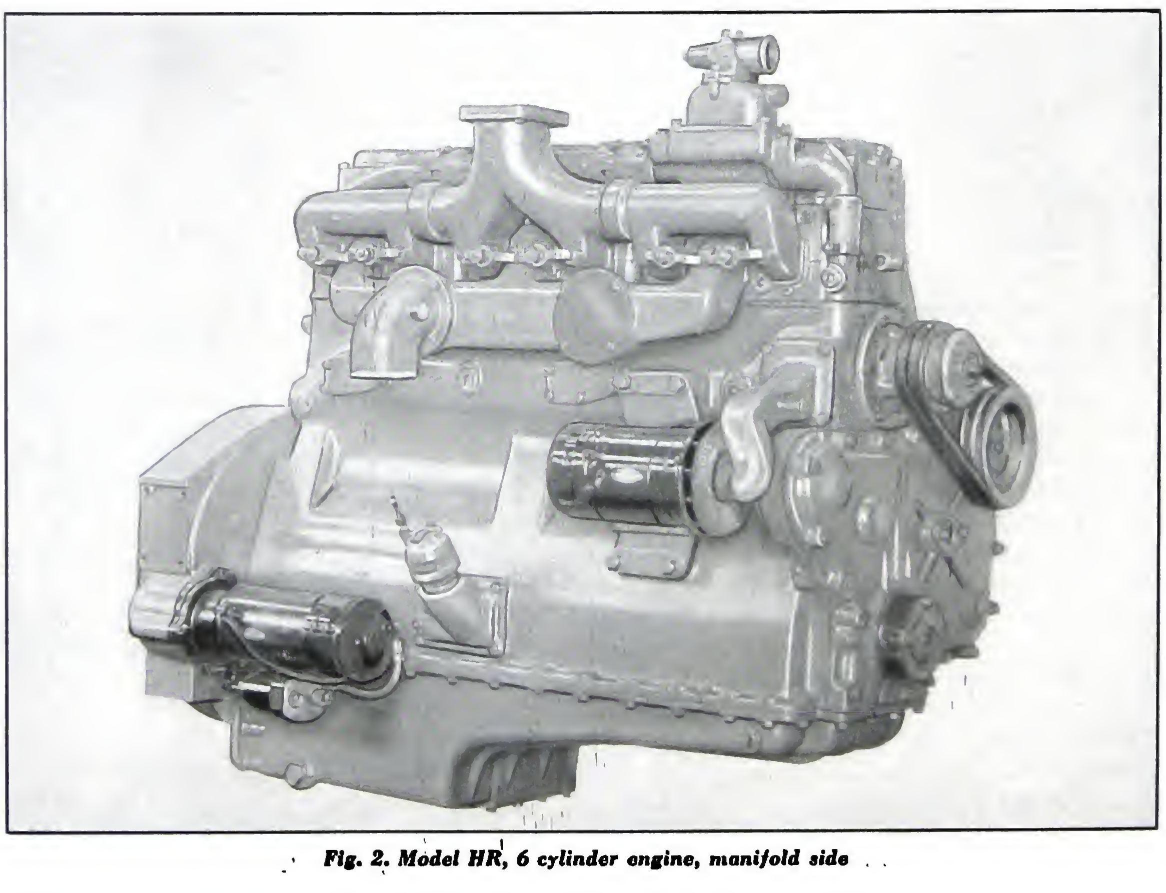


Fig. 2. Model HR, 6 cylinder engine, manifold side

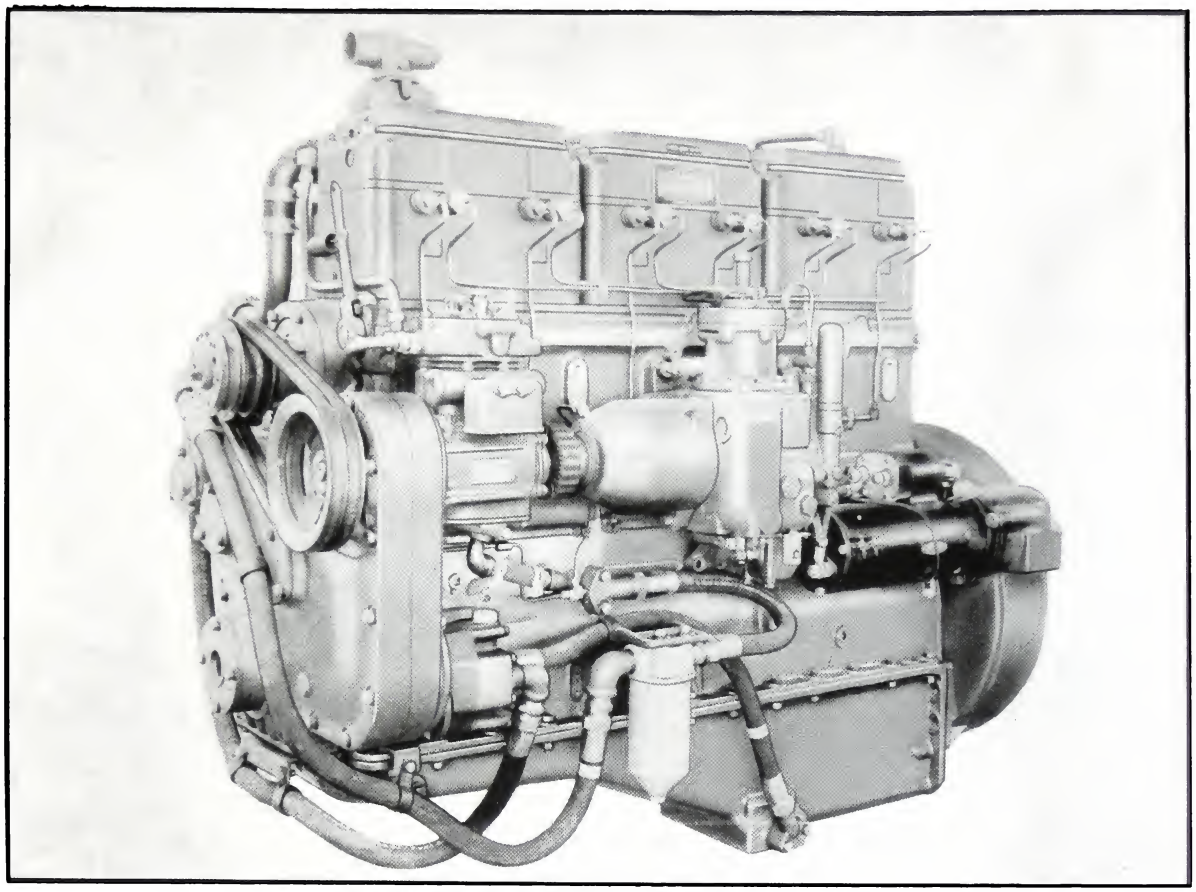


Fig. 3. Model HS, 6 cylinder engine, fuel pump side

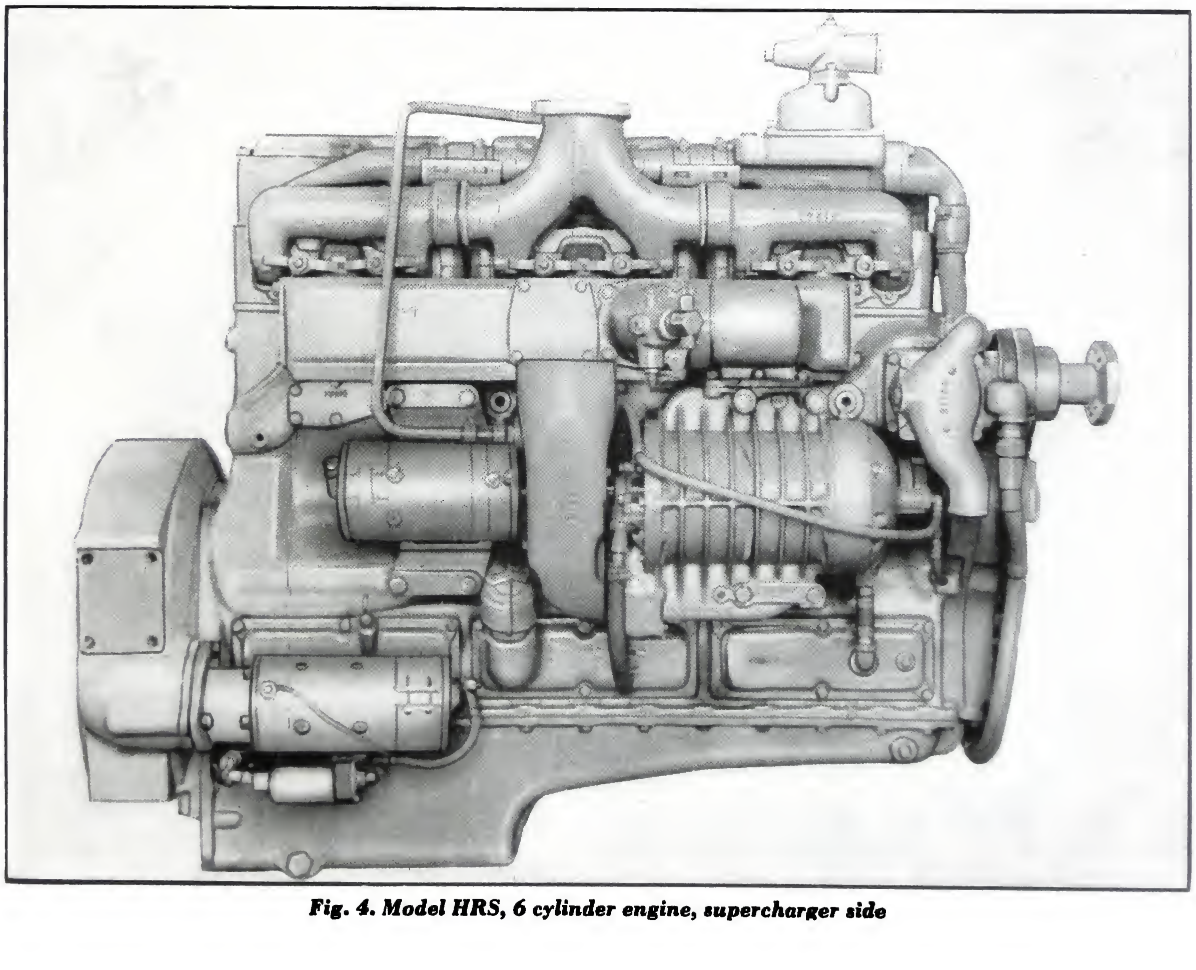


Fig. 4. Model HRS, 6 cylinder engine, supercharger side

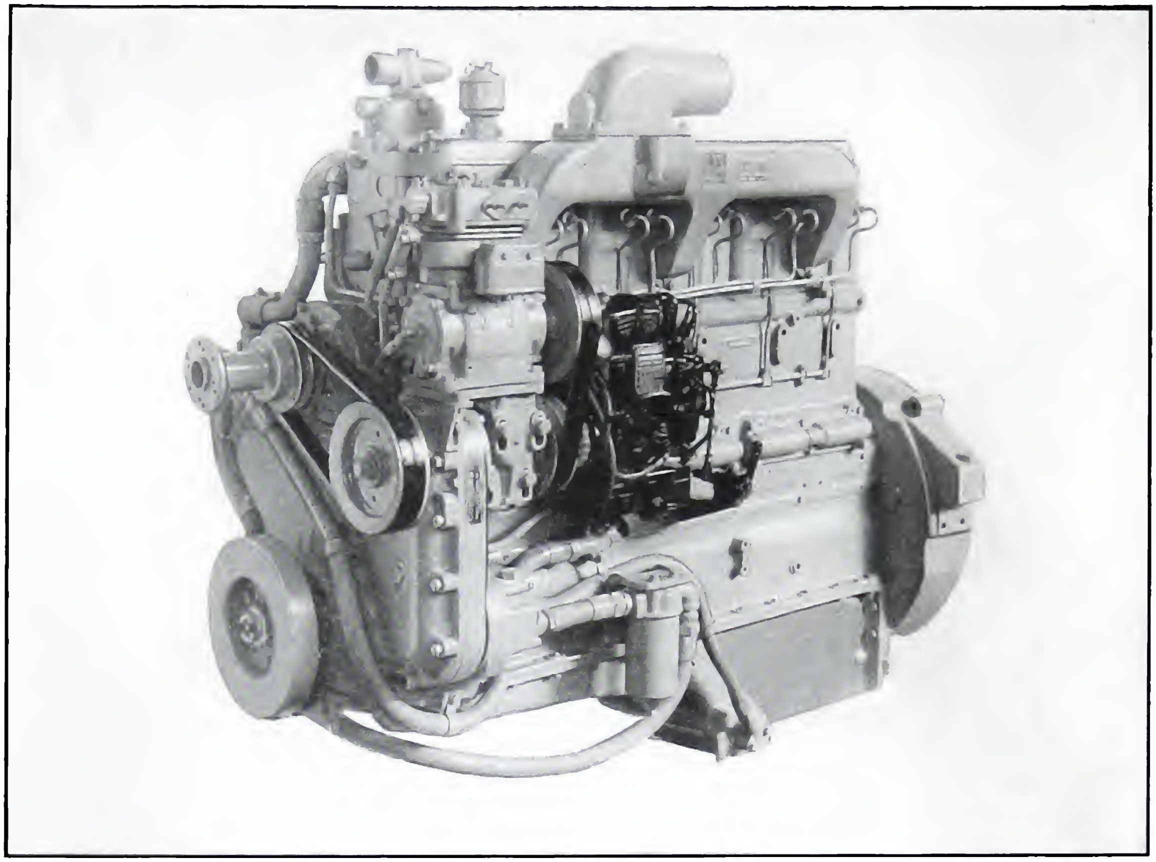


Fig. 5. Model NH, 6 cylinder engine, fuel pump side

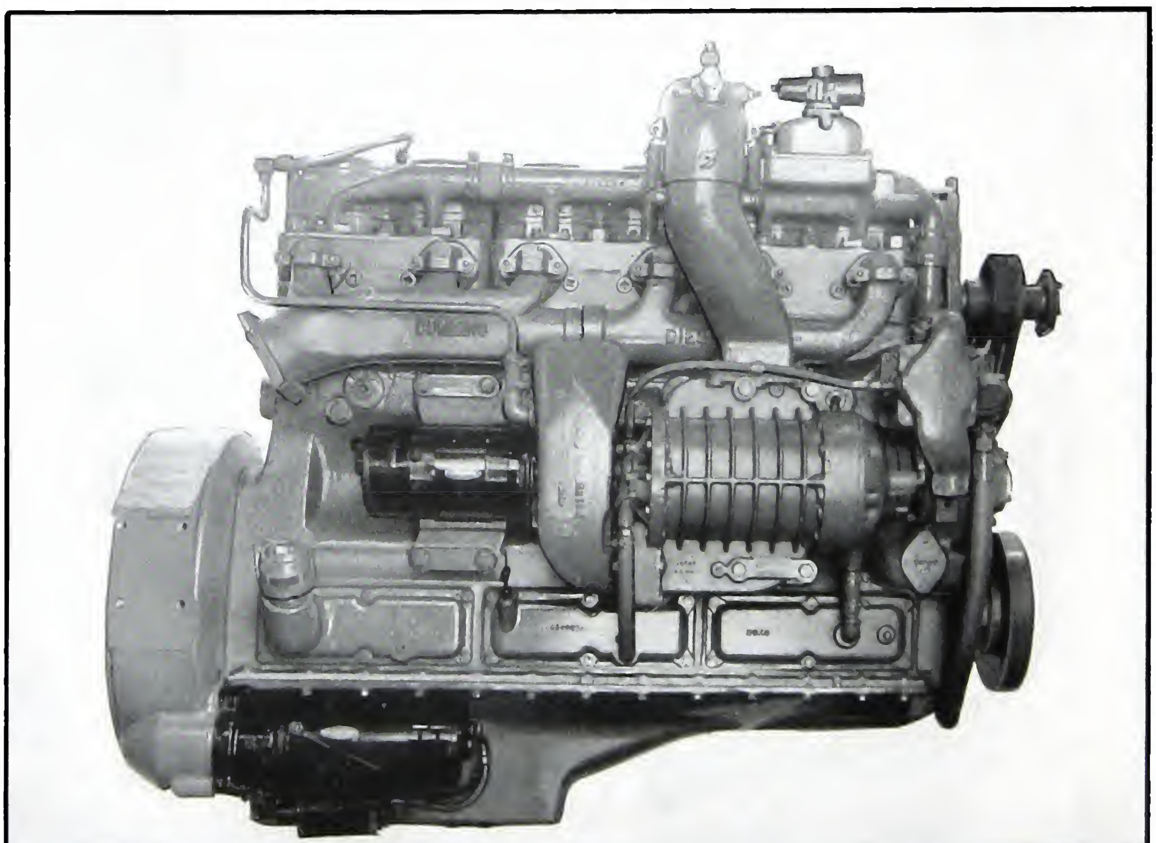


Fig. 6. Model NHS, 6 cylinder engine, supercharger side

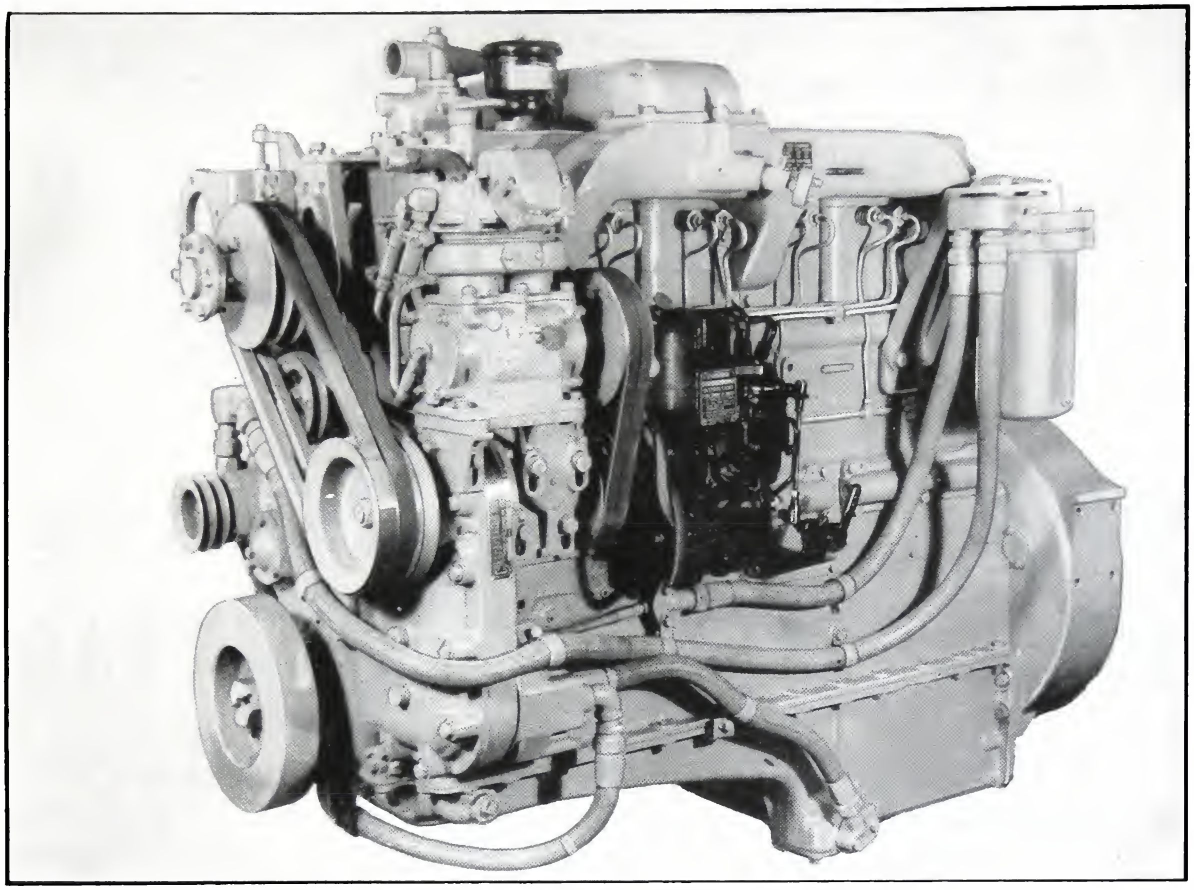


Fig. 7. Model NHRS, 6 cylinder engine, fuel pump side

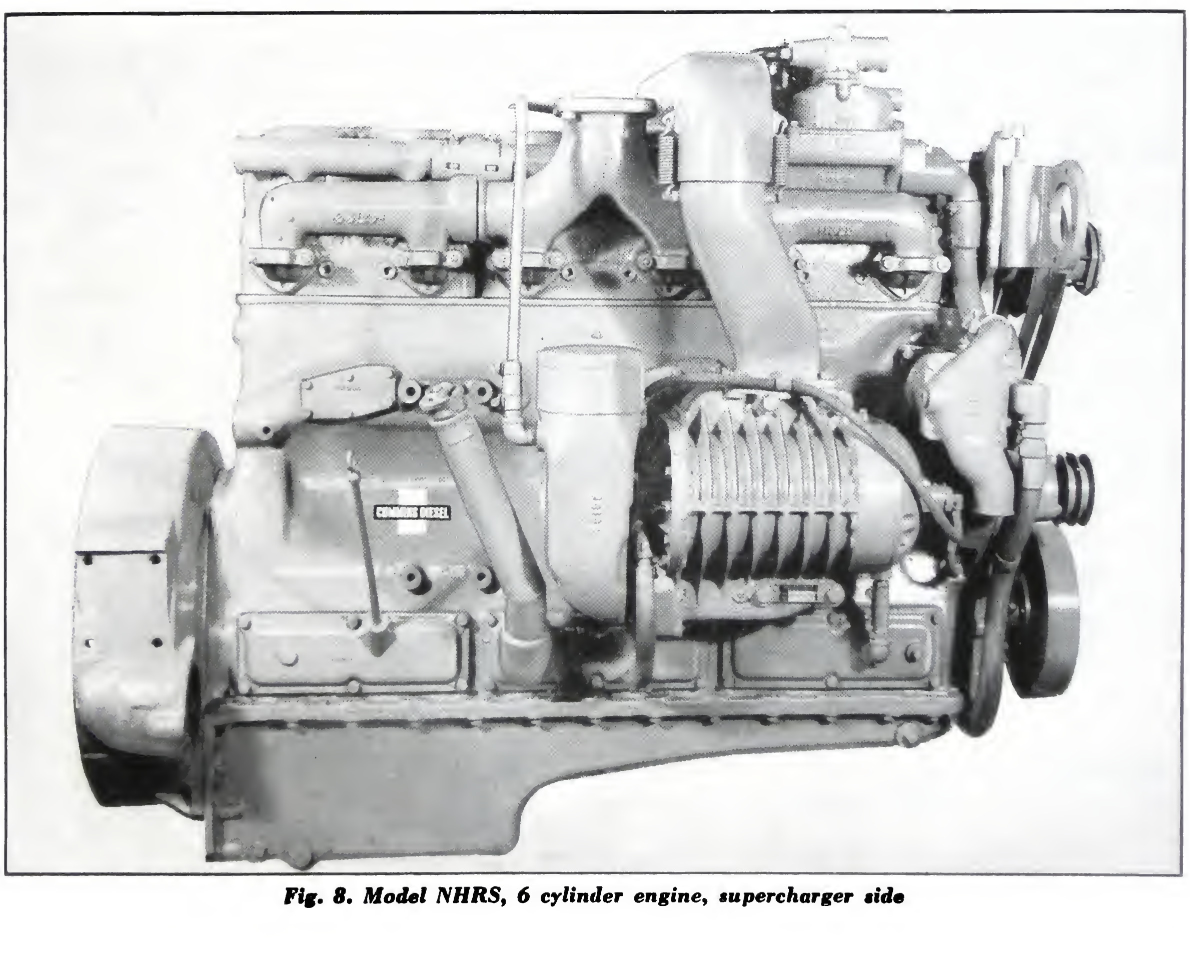


Fig. 8. Model NHRS, 6 cylinder engine, supercharger side

Warranty

CUMMINS

100,000 MILES OR ONE YEAR

THE ENGINES FURNISHED BY

CUMMINS ENGINE COMPANY, INC.

are warranted to be free from any defects in workmanship and material under normal use and service, our obligation under this Warranty being limited to replacing or repairing at our factory in Columbus, Indiana, any part or parts returned to us with transportation charges prepaid, which our examination shall disclose to our satisfaction to have been thus defective, within the first twelve months or the first 100,000 miles of operation, whichever shall first occur, from date of delivery of the engine to the original purchaser, this Warranty being expressly in lieu of all other Warranties express or implied and of all other obligations or liabilities on our part. We neither assume nor authorize any other person to assume for us any other liability in connection with the sale of our engines. ¶ This Warranty shall not apply to any part or parts which shall have been altered or repaired outside of our factory, nor to parts which have been subjected to misuse, abuse, neglect, accident or to damage caused by overspeeding, nor to part or parts not manufactured or approved by us, nor to part or parts of engines improperly applied or installed. Any improper installation or application, or any substitution of parts not manufactured or approved by us, shall void all Warranties express or implied on our part. ¶ We make no Warranty as to normal wear and tear, nor do we agree to be liable for loss of time to the user while the engine or other equipment is out of commission, nor for any labor or other expense, damage or loss occasioned, or claimed to be occasioned, by such defective parts. ¶ We make no Warranty in respect to starters, generators, transmissions, clutches, compressors, or any accessories not manufactured by us. These are usually warranted by their respective manufacturers.

CUMMINS ENGINE COMPANY, INC.

CUMMINS ENGINE COMPANY, INC. SEAL COLUMBUS, IND.

R. E. Huthsteiner

PRESIDENT

SECTION I

The Unit Rebuild Plan Engine Disassembly

Cummins
H, HS, HR, HRS, NH, NHS, NHRS
Diesel Engines

Introduction

When a new engine is first started its parts begin to wear at the bearing points. At first this wear is negligible, but after a few hundred million crankshaft rotations wear progresses to such an extent that many engine parts must be replaced. The cost of new parts, labor and loss of revenue from down time may make replacement of worn parts a major item of operation expense. Fortunately, this source of expense can be controlled to a very appreciable extent by observing a few simple rules:

1. Reduce the rate of wear by:
   a. Providing the best lubrication.
   b. Maintaining cleanliness.
   c. Maintaining proper operating temperatures.
   d. Avoiding overloads or excessive high speeds.
2. Avoid costly emergency repairs by practicing periodic preventive maintenance to fit work conditions.
3. Reduce parts replacement costs by careful inspection of worn parts before discarding.
4. To increase the periods between overhauls:
   a. Use genuine parts as supplied by the engine manufacturer.
   b. Have new parts installed to manufacturer's specifications in a properly equipped shop and by modern work methods.
5. Maintain an adequate supply of rebuilt engine units to reduce down time.

This shop manual contains technical data and methods necessary for complete unit rebuilding of Cummins H and NH series diesel engines. While some of the material contained herein is being printed for the first time, it is not new. It is an accumulation and selection of material from the factory and from repair shops devoted exclusively to the rebuilding of Cummins engines. Experience has proved that, in those shops using these methods, very substantial savings of both labor and materials are effected. In addition, engines rebuilt by standardized procedures should give longer periods of satisfactory service.

The average repair shop can not have all the facilities of a factory to do the machining operations. At the same time the shop must be sufficiently equipped with precision machines and tools to duplicate factory standards if rebuilt units and rebuilt engines are to go out and do a good job. For that reason we have designed special service tools as indicated in this manual. Most of these tools can be purchased directly from Cummins dealers. Others can be made in the shop from our prints. Still others are available from tool manufacturers.

Each engine unit is treated for complete disassembly, cleaning, inspection, rebuilding and

assembly. It is not to be supposed that all work operations indicated on all units will need to be done on any one engine. Intelligent inspection will decide what operations are to be performed. After the mechanic has become thoroughly acquainted with the instructions he should be able to perform them in their proper sequence by referring only to the recap sheets in Section XIV.

Loose references to "H" engines will apply to H, HS, HR, HRS engines, and "NH" references will apply to NH, NHS, NHRS engines. This procedure will be followed in this manual to avoid long lists of models at each reference.

UNIT REBUILDING

Cummins engines are particularly adapted to unit rebuilding. Each model is an assembly of units, and with the exception of the cylinder block group, Unit I, and the flywheel housing, any unit can be removed and replaced by a new unit without removing the engine from its mounting. Even in the case of Unit I; main bearings, connecting rods, pistons and rings and cylinder liners can be changed without removing the block from its mounting. Periodic preventive maintenance is not only possible, it is logical and economical with Cummins engines.

Unit rebuilding must be done to exacting standards if it is to accomplish its purpose—*lower maintenance costs.* The proper tools must be available and be used in the right way to insure quality work at a reasonable cost. Rebuilt units should be carried in stock by the operator so they will always be available as needed. Then, whether it is a frame overhaul or a complete overhaul, the unit need not be down more than a few hours.

UNIT NUMBER IDENTIFICATION: Each of the engine units has been assigned an identification number. This number is represented by the first two of the four digits shown. The third and fourth digits represent the assemblies in the unit. Parts stock rooms can be arranged to good advantage using this system. From time to time these reference numbers will be used in this manual. The unit descriptions and numbers follow:

01 Engine Block Group

0101 Cylinder Block and Liners
0102 Crankshaft and Main Bearings
0103 Connecting Rod and Bearings
0104 Piston
0105 Rear Cover
0106 Camshaft
0107 Idler Gear
0108 Gear Case Cover
0109 Compression Release
0110 Hand Hole Cover

02 Cylinder Head Group

0201 Cylinder Head

03 Rocker Lever Housing

0301 Rocker Lever Housing
0302 Rocker Lever Housing Cover

04 Cam Follower Housing And Lever Group

0401 Cam Follower Housing
0402 Push Rods

05 Fuel System

0501 Fuel Filters
0502 Fuel Pumps
0503 Fuel Pump Housing and Control Levers
0504 Distributor
0505 Cam Rocker Lever
0506 Vertical Lever
0507 Fuel Pump Main Shaft
0508 Float Chamber
0509 Gear Pressure Pump
0510 Overspeed Stop
0511 Governor or Governor Drive
0512 Governor, Hydraulic
0513 Throttle Linkage
0514 Fuel Gauge

06 Fuel Tubing, Connection And Injectors

0601 Fuel Tubing, Injector
0602 Fuel Inlet Connection
0603 Fuel Drain Connection
0604 Injector

07 Lubricating System

0701 Oil Pan
0702 Filter, Full Flow
0703 Filter, Bleeder Type
0704 Lubricating Oil Tubing
0705 Oil Cooler
0706 Lubricating Oil Pump
0707 Lubricating Oil Scavenging Pump
0708 Lubricating Oil Gauge

08 Cooling System

0801 Water Pump
0802 Water Manifold
0803 Thermostat and Water Piping
0804 Water Pump, Fan Drive Pulley and Belts
0805 Fan and Hub
0806 Sea Water Pump
0807 Bilge Pump
0808 Belt Shield
0809 Radiator, Heat Exchanger
0810 Water Connection
0811 Water System Gauge
0812 Water Vent Assembly

09 Driving Units

0901 Generator Drive
0902 Supercharger Drive Units
0903 Jackshaft

10 Air Intake System

1001 Air Filter and Silencer
1002 Supercharger and Connections
1003 Preheater
1004 Air Intake Manifold

11 Exhaust System

1101 Exhaust Manifold
1102 Exhaust Piping
1103 Exhaust Silencer and Mufflers

12 Air Starting And Braking

1201 Air Compressor
1202 Vacuum Pump
1203 Auxiliary Air Starting
1204 Distributor and Piping

13 Electrical Equipment

1301 Cranking Motor
1302 Magnetic Switch
1303 Starting Switch
1304 Generator
1305 Voltage Regulator
1306 Solenoid and Step Voltage Controls
1307 Wiring, Engine
1308 Electrical Gauges

14 Complete Engine Assembly

15 Instrument Panels—Engine

1501 Instrument Panel
1502 Wiring, Instrument Panel
1503 Tubing, Instrument Panel
1504 Safety Controls

16 Engine Mounting And Adaptation

1601 Support, Front Engine
1602 Vibration Damper
1603 Flywheel Housing
1604 Flywheel
1605 Sub-base, Hood Frames
1606 Power Take-off, Front
1607 Marine Gear
1608 Generator, Direct Current
1609 Generator, Alternating Current
1610 Main Generator Controls

WORK FLOW: Many standard production practices should apply to unit rebuilding to insure low rebuilding costs as well as a better grade of work.

The unit rebuilding shop should be independent of and separated from the engine repair and installation part of the shop. Each man should become a specialist in his work. Skill can be attained quickly in specialized work.

All units should be (1) steam cleaned on the outside, (2) disassembled, (3) cleaned in solvent, (4) inspected and (5) have new parts assigned, as needed, before actual rebuilding.

Fig. 1-1. Unit rebuild shop

Each unit should be identified by job number.

One man should be responsible for collecting parts lists and delivery of parts to the proper bin. This will avoid bottlenecks at the parts room.

Special tools should be charged to the job, kept on the job and be immediately available for the job. A tool rack with a hinged cover can be located on the back of the workman's bench. When he raises the cover in the morning the tools are immediately available at his finger tips, just where they were yesterday and he is ready for work. As much as 30% of a workman's time can be wasted if he rummages through boxes or drawers to get his tools or if he checks them in and out of the stock room. One common tool rack, with tool outlines painted on it, can be used for a group of men, if the tools are not being constantly used. ST-136 Main Bearing Bore Checking Bar is an example of such a tool.

Unit rebuild parts lists or check lists should be furnished to (1) reduce copy work, (2) make failure frequency checks easy, (3) provide a check against inventory, (4) show what parts have been replaced in each unit, (5) save time and prevent the errors that occur with one or more copies or lists—from the stock room through the front office and (6) make it possible to indicate "parts changes" on all sheets and eliminate the general confusion that may exist in ordering, invoicing, etc., when parts changes are omitted or overlooked. The parts man should keep all parts change notices indicated on his "master sheet" and make the comparison and changes on all copies at once. The next reprint of the sheets would include all revisions.

CLEANING: The old proverb about cleanliness certainly applies to engine and unit rebuilding. Dirt, of one form or another, remains the major cause of engine failures. The unit rebuild shop should be so arranged that it can be cleaned easily and look clean at all times. Paint, lighting and shop arrangement will help to keep the shop looking clean and orderly. No day is ever so rushed that some time can not be profitably spent in shop cleaning.

The next problem is to keep the dirt out of the shop. If units are cleaned thoroughly before they are brought into the unit rebuild department, there will be less dirt to take out.

Some units require special cleaning facilities not common to others.

Steam Cleaning: A good portable, electric or fuel oil heated steam cleaner has a place in every shop. The portable cleaner can be used in the shop or taken out in the yard to remove most of the accumulation of dirt. After disassembly of the units they can be steam cleaned again to remove most sludge and grease. This will make an appreciable saving in cleaning solvent.

The Cleaning Tank: Besides having a good cleaner and a tank of sufficient capacity for the work, there are two other requisites for satisfactory solvent cleaning. The solution must be (1) heated to approximately 180° F - 200° F and it must be (2) kept in constant agitation.

With sufficient heat, the agitation can be accomplished by built-in baffle plates. Violent convection currents are possible with a properly built and properly heated tank.

After unit disassembly, put all small parts in wire mesh baskets and steam clean and then immerse in the cleaning tank for as long as necessary to do a thorough job of cleaning. Larger parts can be lowered directly from the chain lift and hooks into the tank.

Bearing shells and aluminum parts should not be cleaned in the hot solvent. Most effective solvents damage aluminum or babbitt.

Dry all cleaned parts with compressed air, if needed. The heat from the hot solvent tank will generally cause drying without the use of air.

Complete cleaning should not precede rebuilding by a period long enough to permit rusting of parts. A light oil dip will protect against rusting.

Blasting: **Scale on cylinder liners and certain other parts can be removed easier and more completely by sand blasting. Some shops make a specialty of this type custom cleaning. Aluminum pistons can be cleaned very satisfactorily by using seeds or ground corn cobs instead of sand in a blasting machine.**

CAUTION: DO NOT SAND BLAST CYLINDER BLOCKS, OIL PANS OR OTHER PARTS THAT MIGHT HOLD SAND PARTICLES AND ALLOW DISTRIBUTION THROUGH THE LUBRICATING SYSTEM.

INSPECTION: In any unit rebuild shop there should be two standards of inspection. The first inspection should determine what parts can safely be used during the next period of service. All used moving parts of the engine will show some wear. How much has it worn? How fast does it wear? What will be the effect on engine operation if worn parts are used? What shall be the worn limits? All these questions must be answered by the inspector in determining whether it will be more economical to use the worn parts or to replace them with new ones.

The second standard of inspection is easy. All new parts should be replaced or machined to pass factory standards of new parts.

The combination of these two inspection standards, if properly done, will result in rebuilt engines that will perform comparably with new engines, both as to satisfactory performance and length of periods between rebuilding.

This section is not to be devoted to teaching or developing inspection. Inspection and methods of inspection and gauging can become very highly specialized. It is not to be expected that every shop should be equipped with instruments capable of gauging to millionths of an inch. Neither is it expected that the average mechanic should be capable of using such equipment. However, it is necessary that every shop should have both the equipment and the men necessary to gauge parts to the limits indicated in this manual, if that shop is to do quality unit and engine rebuilding. As far as possible, one man in each shop should be responsible for inspection in that shop. This method of handling inspection will result in greater uniformity of standards as well as substantial time and material saving.

Inspection Equipment: **1. Plug gauges can be used satisfactorily to gauge newly machined round bores up to approximately 2 inches in diameter. Plug gauges can not be used to determine wear of bores, if the wear is uneven. Plug gauges wear and must be replaced when worn beyond usable limits.**

2. Dial bore gauges with dial indicators can be purchased and used for most bores of Cummins engine parts. These gauges, if used, must be set with standard ring gauges. A complete set of bore gauges and check ring gauges is rather expensive.

3. Telescoping inside gauges, while not quite as accurate as dial bore gauges, can be used satisfactorily in conjunction with outside micrometers to gauge small bores. A set of 3 telescoping gauges can be purchased to gauge all bores from ½″ to 2″. They are comparatively cheap. Fig. 1-2.

4. Inside micrometers can be used to accurately gauge bores from 2″ to 12″. They must be checked regularly with standards or with outside micrometers set to standards.

5. Outside micrometers should be of the best quality originally and, to be of any value, they must be kept adjusted to checked standards.

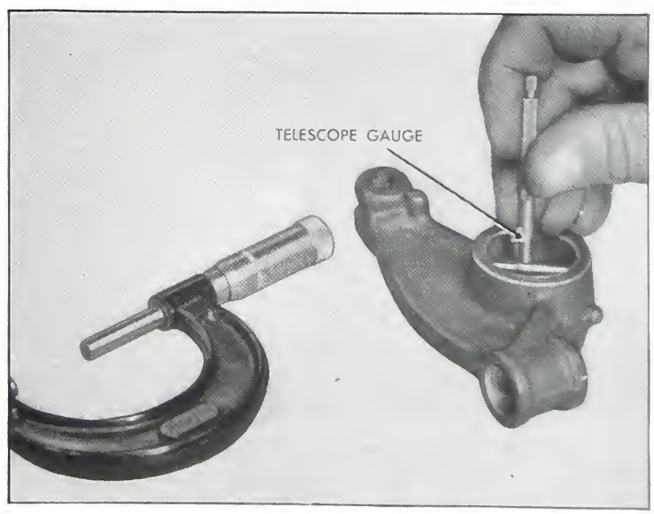


Fig. 1-2. Gauging small bore with telescope gauge and micrometer

ENGINE DISASSEMBLY

General Instructions

DRAIN WATER AND OIL: 1. Drain lubricating oil from oil pan, oil filters, oil cooler, governor (if hydraulic type), and air compressor.

2. Drain fuel oil from fuel pump, fuel filters and fuel lines.

3. Drain water from cylinder block, oil cooler and heat exchanger.

CLEAN ENGINE EXTERIOR: 1. After removal of generator, cranking motor and other electric equipment, but before removal of remaining units, the engine should be thoroughly cleaned with a steam jet. Nobody really likes to work on a dirty engine and a little time spent in cleaning will be made up quickly during disassembly.

2. A portable, fuel oil or electric heated steam cleaner such as the one illustrated in Fig. 1-3 is very satisfactory for general use on Cummins engines. This type cleaner can be used either in the cleaning room or in the yard.

3. In addition to actual time saving effected by engine cleaning, various inspections can be made during disassembly, if surfaces are clean.

Fig. 1-3. Steam cleaning the engine

USE THE PROPER TOOLS: 1. Air or other speed wrenches are particularly adapted to disassembly operations.

2. A work bench with tool racks and proper layout of tools will save both time and energy.

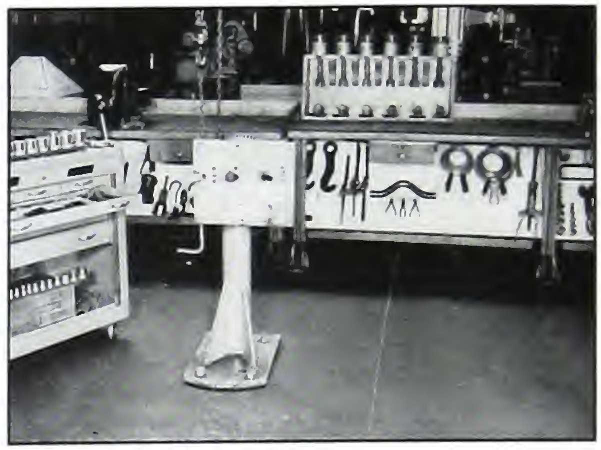


Fig. 1-4. Use proper tools

AVOID ACCIDENTS: 1. Never compromise by using the wrong size wrench or a pair of pliers or a "knuckle buster." Carelessness is the cause of most accidents to workmen as well as to machinery and parts.

2. Two men — working together — can disassemble an engine more than twice as fast as one man. They can help each other with manifolds, supercharger, fuel pumps and other heavy parts to avoid personal injuries and damage to engine parts.

3. Keep the engine at the right height. Do not lay it on the floor. Use an engine stand or skid for the engine. A good engine stand can save 25% in time and effort in disassembly. Fig. 1-5.

4. Never take a chance on unsafe lifting equipment.

KEEP RELATED PARTS TOGETHER: 1. Put all bolts, capscrews, and other small parts with related units in fine meshed wire baskets.

2. Tag each unit and each basket of small parts with the job number, or some other identification to insure proper routing.

PROTECT MACHINED SURFACES: Never allow cylinder head or block mating surfaces—or any other finished surfaces—to become scratched or marred from contact with sharp edges of other parts or with concrete floors, etc.

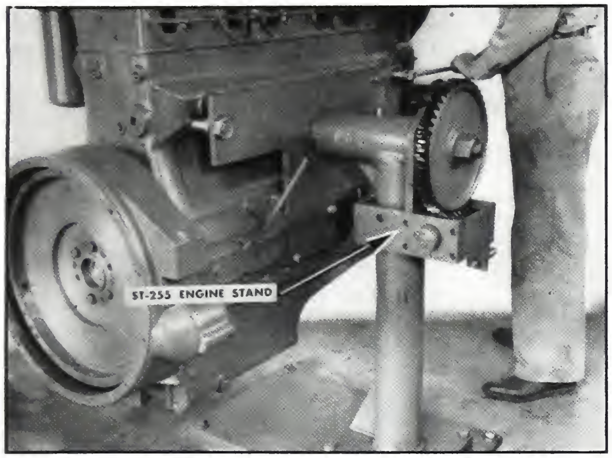


Fig. 1-5. Engine stand

Removal Of Engine Units:

Remove all units and parts from the cylinder block group in the following order and with special precautions as noted. Some of the units indicated are used only on special engine models.

The following instructions apply particularly to the NHRS engine. Certain engine units such as supercharger, vibration damper, oil cooler, etc., are not always used on some other engine models.

After removal, clean the exterior of units thoroughly with a steam jet and dry with compressed air.

Removed units should be sent to storage bins or to unit benches for complete disassembly. After disassembly, all except aluminum parts should be put in wire mesh baskets and brought back to the cleaning room for final complete cleaning in heated, circulating solvent just prior to inspection and rebuilding. This procedure is recommended to prevent damage from rust. If cleaned parts are to be stored, they should be flushed and protected by a light film of oil.

Each unit should be identified by engine serial or job number from the time it is removed until it is rebuilt and reassembled to an engine.

WIRING: 1. Remove the wire leads from terminals or generator, cranking motor, solenoid switch, cold starting electrodes, regulator, remote controls, etc., as used.

2. Remove all other electric controls.

GENERATOR: 1. Remove the capscrews from the generator bracket and lift the generator and bracket from the drive coupling.

2. Remove the bracket from the generator.

CRANKING MOTOR: The cranking motor is mounted on the flywheel housing with three capscrews. By removing these three capscrews, the motor with its mounting spacer may be pulled from the housing.

Steam clean the exterior of the engine.

SUPERCHARGER CONNECTIONS: 1. Loosen and remove the four nuts from the studs which secure the supercharger connection to the intake manifold. Using a screw driver, pry off the springs from the supercharger connection to the supercharger outlet. Springs are used at this connection to prevent distortion of the supercharger when the connection is installed.

2. The vapor suction tube connects one of the rocker housing covers with the supercharger air intake. Remove the tube and connections.

3. Remove the heat shield and supercharger outlet.

CAUTION: INLET AND OUTLET TO THE SUPERCHARGER SHOULD BE KEPT COVERED WITH PLATES OR GUMMED PAPER TO KEEP FOREIGN OBJECTS OUT OF THE SUPERCHARGER. DO NOT STUFF RAGS INTO PORTS.

EXHAUST MANIFOLD: Remove the nuts and clamps which secure the exhaust manifold to the cylinder heads, and lift off the manifold.

SUPERCHARGER: 1. Remove the oil filler tube and cover plate from the cylinder block.

2. Disconnect and remove the lubricating oil supply and drain lines from the supercharger and hand hole covers.

3. While supporting the supercharger to keep it from falling, remove the mounting capscrews from the supercharger and cylinder block.

4. Disengage the supercharger coupling from the drive unit and lift from the engine.

OIL COOLER: 1. Disconnect the water inlet and by-pass connections to the oil cooler and remove them from the engine.

2. Disconnect the lubricating oil line connections to the oil cooler.

3. Remove the mounting capscrews that secure the oil cooler to the cylinder block and lift the cooler from the engine.

ENGINE STAND: 1. Remove the metering pin at the flywheel end of the cylinder block on the water manifold, and attach the engine to ST-255 stand at this hole, on the supercharger mounting pads, and at the holes for the center hand hole cover as shown. Use ST-125 lifting fixture to lift the engine. Hooks of this fixture engage bosses between cylinder heads.

FAN AND PULLEY: 1. Remove the fan from the fan pulley.

2. Loosen the adjusting screw and remove the fan hub, pulley and belts from the mounting bracket.

WATER PUMP: 1. Remove the bell crank arrangement, when used, from the rocker housing and compression release lever.

2. Loosen and remove the capscrews that hold the fan bracket support to the rocker housing.

3. The fan bracket on NH engines is also a clamp ring to secure the water pump. Loosen the six capscrews in the clamp ring.

4. Using a screw driver, in the holes provided in the water pump housing, turn the water pump to the lowest point of its eccentric to loosen the water pump belt.

5. Remove the fan bracket, fan bracket support, water pump and belt from the cylinder block.

LUBRICATING OIL STRAINER AND LINES: 1. Either the Nugent bag-type or the Air-Maze screen-type strainer may be used. Remove the lubricating oil lines and the capscrews which connect the strainer and bracket to the cylinder block and remove both the strainer and bracket from the engine.

2. Remove all remaining lubricating oil lines from the oil pump, oil cooler and oil pan.

INTAKE MANIFOLD: Remove the nuts and lockwashers from the studs at each connection of the air intake ports and lift the intake manifold from the engine.

FUEL PUMP: 1. Remove all fuel supply and drain lines from the fuel pump, inlet connections and priming pump.

2. Disconnect the throttle bracket linkage from the fuel pump and remove the bracket from the cylinder block or pump bracket.

3. Disengage the drive coupling chain; remove fuel pump mounting capscrews and lift the pump from the block.

4. If the single disc pump is used, screw a special lifting nut on the tachometer guide of the fuel pump, before removing the mounting capscrews, so it can be lifted from the engine with a hoist.

AIR COMPRESSOR: 1. Disconnect and remove the air intake line from the air compressor and supercharger inlet.

2. Remove water pipes from the air compressor.

3. Disconnect the lubricating oil lines from the air compressor.

4. Loosen the belt adjustment capscrews.

5. After removing the mounting capscrews and lockwashers from the compressor support, disengage the drive belts and lift the compressor from the engine.

FUEL PUMP AND AIR COMPRESSOR DRIVE: 1. Use a Plomb puller or ST-160 Puller to pull the water pump drive pulley from the air compressor and fuel pump drive.

2. Remove the five capscrews and lockwashers which hold the fuel pump and compressor drive to the gear case. Use a lead hammer or wooden block to loosen the drive from the gear case, and remove.

FUEL PUMP MOUNTING BRACKET AND DRAIN MANIFLOD: 1. Remove the two capscrews from the top of the mounting bracket and the two from the clamp at the bottom of the bracket. Pry the bracket from the dowels.

2. Disconnect the drain line from the drain connections. Remove the clamps which secure the drain manifold to the cylinder block, and lift off the drain manifold.

LUBRICATING OIL PUMP: 1. Loosen and remove the four nuts from the studs which hold the lubricating oil pump to the gear case. The nut closest to the cylinder block at the bottom must be loosened last and removed as the pump is pulled back from the gear case.

2. Remove the lubricating oil inlet flange from the cylinder block and the lubricating oil line leading from the flange to the air compressor. (On older engines where by-pass valve is not

built in the lubricating oil pump, a by-pass valve is built in this flange).

FLYWHEEL: 1. Remove the lock wires and take out the flywheel capscrews. Insert two manifold studs through two opposite capscrew holes in the flywheel and screw them into the crankshaft flange. These will provide a support for the flywheel during its removal.

2. In the two holes provided, place $\frac{1}{2}''$-13 capscrews $2\frac{1}{2}''$ long, threaded their entire length. By alternately turning in these capscrews, the flywheel will be pulled from the crankshaft. See Fig. 1-6.

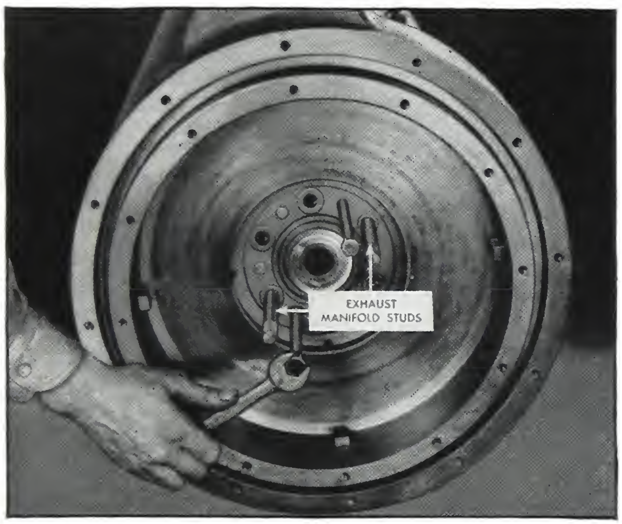


Fig. 1-6. Pulling flywheel

FLYWHEEL HOUSING: Remove the capscrews from the flywheel housing and with light blows from a block of wood or soft hammer, drive the housing from the dowels.

WATER MANIFOLD: Remove the two capscrews from the water by-pass connection at the cylinder block. Then remove the two capscrews from each foot on the water manifold and lift the manifold assembly from the engine.

ROCKER HOUSING COVERS AND HOUSINGS: 1. Remove the rocker arm housing covers by taking out the three capscrews holding each cover to the housing.

2. Remove the lubricating oil pipe cap and gasket.

3. Remove the seven stud nuts from each rocker housing assembly and lift the assembly from the engine by grasping the end of each injector rocker.

PUSH RODS: Remove the push tubes by lifting them from their sockets.

INJECTORS AND CONNECTIONS: 1. Unscrew and remove the fuel inlet and drain connections.

2. After removing the injector hold down nuts lift the injectors from the cylinder heads. BE EXTREMELY CAREFUL NOT TO BRUISE THE TIP.

3. Clean exterior of injectors by washing in mineral spirits and drying with compressed air. Do not steam clean after inlet and drain holes have been exposed.

4. Put injectors and inlet connections in a special rack numbered by cylinders from which they were removed. This may aid in making engine failure analysis. The rack will protect them from damage in handling.

CAM FOLLOWER HOUSINGS: 1. Remove the capscrews from the cam follower housings.

2. Use a small screw driver to pry the housings from the dowels.

CYLINDER HEADS: Remove the cylinder head stud nuts with a heavy duty socket wrench and lift the cylinder head assembly from the studs.

SUPERCHARGER DRIVE: 1. Remove the supercharger bearing retainer cover. On some installations, a longer drive shaft is used and a pulley for an accessory drive is mounted outside the gear cover. This pulley must be removed first when used.

2. Remove the key from the shaft and drive the shaft back with a soft hammer until the drive unit can be removed from the gear case.

VIBRATION DAMPER AND FLANGE: 1. Loosen the lock plates or on early model dampers pull the dowels using $\frac{3}{8}''$-16 capscrews.

2. Remove the six capscrews and lift off the damper. Tap with a soft hammer, if necessary, to loosen from the crankshaft flange.

3. Remove the cotter pin, locknut and lockwashers from the crankshaft.

4. Pull the crankshaft flange from the tapered crankshaft with special puller, ST-250, as shown in Fig. 1-7. This puller will prevent distortion of the flange as it is removed.

OIL PAN: 1. Remove all mounting bolts and capscrews from the oil pan and remove it from the engine.

2. Complete cleaning of the oil pan by submersion in a tank of solvent. DO NOT PUT ALUMINUM PANS IN SOLVENT TANK.

CYLINDER BLOCK GROUP: The parts left on or in the cylinder block; namely the crankshaft and bearings, connecting rods and pistons, rear cover, camshaft and bearings, idler gear, gear case cover, compression release and hand hole covers comprise Unit I and will be treated separately as to complete disassembly and cleaning, inspection, rebuilding and assembly in later section.

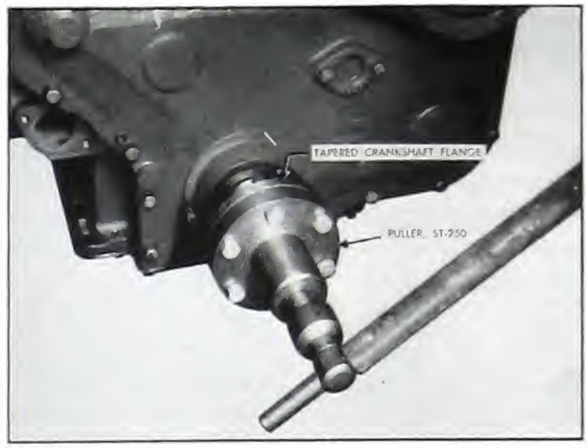


Fig. 1-7. Pulling tapered crankshaft flange

SECTION II

UNIT NO. 1

Cylinder Block Group

DISASSEMBLY

GEAR CASE COVER: 1. Remove the cap screws from the camshaft end bearing and the idler pin support, and pull these parts from the gear case cover. A spacer is used on the camshaft end bearing to regulate camshaft end clearance. Keep spacers with the end bearing.

2. Use a 5/16"-18 cap screw and a piece of tubing or socket to pull the inside threaded dowels from the gear case cover and the cylinder block. Remove all cap screws from the gear case cover and, with light blows from a soft hammer, loosen from the gasket and remove from the cylinder block.

NOTE: Drilled camshafts have an oil regulator plunger at the gear case end of the camshaft. Engines using undrilled camshaft have the pressure regulator in the lubricating oil pump.

CAMSHAFT AND GEAR: Rotate the camshaft gear slightly while pulling the camshaft from the engine. Do not remove the gear from the camshaft.

CONNECTING ROD AND PISTON ASSEMBLIES: 1. Scrape all carbon from the top of the cylinder liners. Pistons on the Cummins Diesel are closely fitted to the liners and failure to clean the liners thoroughly may cause the piston to stick.

2. Remove the connecting rod bolt nuts and knock the bolts from the cap and the rod. Failure to remove the bolts may cause the head of the bolt to catch on the bottom side of the cylinder liner before all the rings clear the liner and thus lock the piston.

3. With a small wooden stick, push the piston and connecting rod from the cylinder liner. Hold the piston as it is being pushed from the liner so that it will not be dropped and damaged.

4. Reassemble connecting rod bolts, cap, and nuts as they are taken out since bearing caps are NOT INTERCHANGEABLE.

5. Tape bearing halves together and identify by number as removed.

6. Remove piston pin snap rings from pistons and knock out the piston pins from pistons and rods.

CAUTION: HEAT ALUMINUM PISTONS IN HOT WATER BEFORE REMOVAL OF PISTON PINS. THIS WILL PERMIT THE PIN TO BE PUSHED OUT EASILY WITHOUT DISTORTING THE PISTON.

OIL PIPES: Insert a pin punch through the holes of the oil pipes, and unscrew them from the block. These oil pipes carry lubricating oil from the oil galley to the upper rocker levers.

CYLINDER LINERS: Use ST-62 puller and a wrench to pull the cylinder liners. It has a lower plate, relieved at the sides, to slide through the liner and engage it at the bottom.

REAR COVER PLATES: Remove the nuts from the two dowel bolts holding the rear cover plates together, and drive out the bolts. Remove mounting cap screws and take off the lower cover plate. The upper cover plate will be taken off after the crankshaft is removed.

IDLER GEAR: 1. Bend back the lock washer tangs and use a 2⅜" wrench to remove the lock nut and idler gear.

2. On non-supercharged engines, remove the washer and screw from the idler gear pin, and pull the idler gear off the pin.

COMPRESSION RELEASE: 1. To remove the compression release shaft, first remove the lock screw at the rear end of the cylinder block and pull the shaft from the block at the lever end. Remove the packing gland and old packing.

2. Remove the cap screws from the compression release bearings, and pull the bearings from the block, if block and bearings are separate.

HAND HOLE COVERS: Remove the hand hole covers, bayonet gauge and breather, or oil filler pipe from the cylinder block.

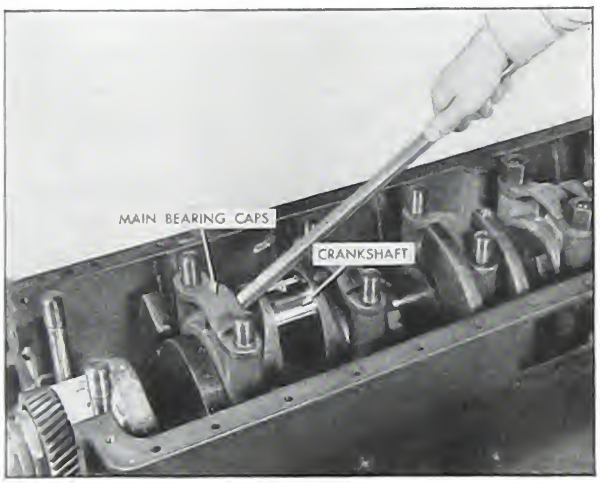


Fig. 2-1. Removing main bearing caps

CRANKSHAFT AND MAIN BEARINGS: 1. Before attempting to remove the main bearing caps turn the engine upside down in the stand.

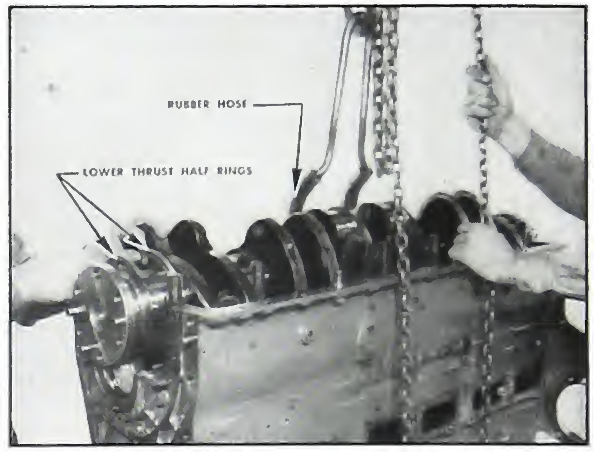


Fig. 2-2. Lifting crankshaft

2. Remove the main bearing stud nuts and, with a small pry bar, loosen each main bearing cap from the dowels and lift from the main bearing studs. Keep nuts with original studs.

3. With hooks protected by rubber hose, or with a rope at two crank throws (Fig. 2-2), lift the crankshaft from the cylinder block. Be very careful to remove the lower main bearings from the crank before lifting.

4. Remove all upper main bearings and dowel rings from the cylinder block.

5. Do not pull the main bearings studs. Because of the interference fit of the threads at the lower end of the stud, there is danger of damaging the threads and ruining the cylinder block, if the studs are removed.

6. Clean all disassembled units and parts with a steam jet and in the solvent tank (except as noted).

INSPECTION

Cylinder Block

CHECK BLOCKS FOR CRACKS AND CORROSION: 1. The cylinder block should be carefully checked for cracks and corrosion. Suspected cracks in the block may be detected by painting with a light film of oil and then, after rubbing off all the oil, painting with chalk dust and alcohol, or "whiting." After drying, chalk dust and oil will make the cracks readily apparent.

2. Corrosion is most likely to occur on the portions of the block which come in closest contact to the cylinder liners. This type of corrosion will be evidenced by pitting. All blocks should be discarded as unsuitable for further use if this pitting is such as to endanger water seals

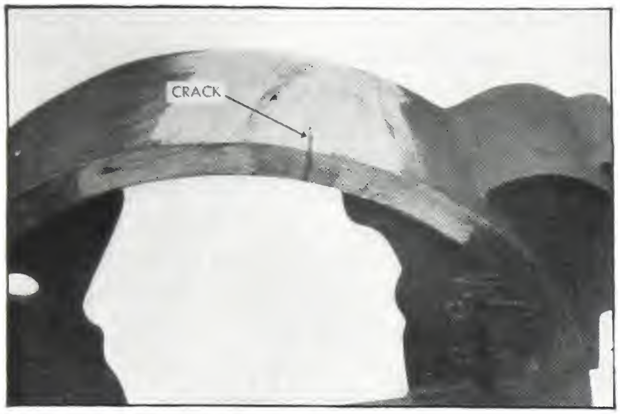


Fig. 2-3. Crack in casting

CHECK LINER COUNTERBORE DEPTH: 1. The counterbore at the top of the cylinder block for the liner flange must be smooth, perpendicular to the cylinder bore and .435/.434 deep.

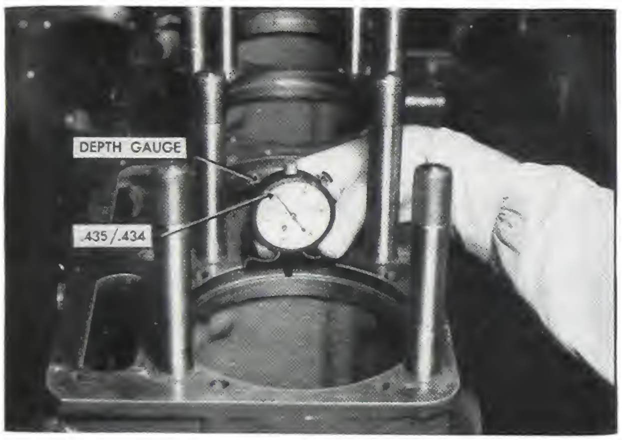


Fig. 2-4. Checking counterbore depth

2. When the cylinder liner is assembled in the block the top of the liner should be .004/.006 above the milled top of the cylinder block.

3. A dial indicator depth gauge should be used to measure the counterbore depth.

CHECK MAIN BEARING PILOT FIT: The main bearing caps must fit in the block with no perceptible clearance or "shake". The milled faces of the cap must always rest squarely on the mating milled portion of the block. Otherwise, the cap would be distorted when tightened down. If the machined recess in the block will not hold the caps securely, the block must be scrapped. (Fig. 2-5)

MAIN BEARING STUDS: 1. Drilled main bearing studs were used on all H and NH engines with bottom oiling of main bearings. Top oiling has been used on NH(S) engines since Serial No. 70015 and on six-cylinder H(S) engines since Serial No. 90063. If the engine has drilled studs the passages must be open and clean.

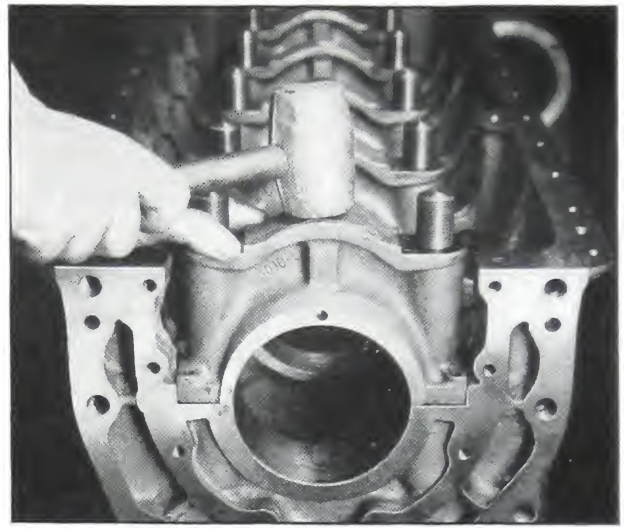


Fig. 2-5. Checking main bearing pilot fit in block

2. If studs are damaged or hand-loose mark them for replacement; otherwise do not remove them. When new studs are used they should be installed to a height of 5 21/32″ to 5¾″ with a minimum of 50 foot-pounds torque.

NOTE: 75/150 foot-pounds torque may be required to install new studs in cylinder blocks dated 4-1-51 or later. *Studs to be used should always be in position before checking main bearing bores and alignment.*

CHECK MAIN BEARING BORE AND ALIGNMENT: 1. Run a cleaning rod and cloth through the oil passages of the block. After determining that they are clean, replace all oil seal plugs in proper position.

2. Assemble main bearing caps, lock plates and nuts in position and tighten the nuts to operating tension by the template method as described at the end of this unit section, Page 2-12.

3. Gauge main bearing bores with a cylinder bore gauge or inside micrometers—properly adjusted to standards. Gauge vertically, diagonally and horizontally. The bore must be 4.749/4.750 in diameter.

4. Check the alignment of main bearing bores with ST-136. ST-136 is a finely ground checking bar 4.747 in diameter. If the caps are properly

tightened in place and the bores are in alignment the checking bar will pass through all seven bores and turn freely. See Fig. 2-6. If the bar will not go through all bores, check for burrs or other possible interference. Never decide that the bores are out of alignment until you know that all other possibilities have been eliminated.

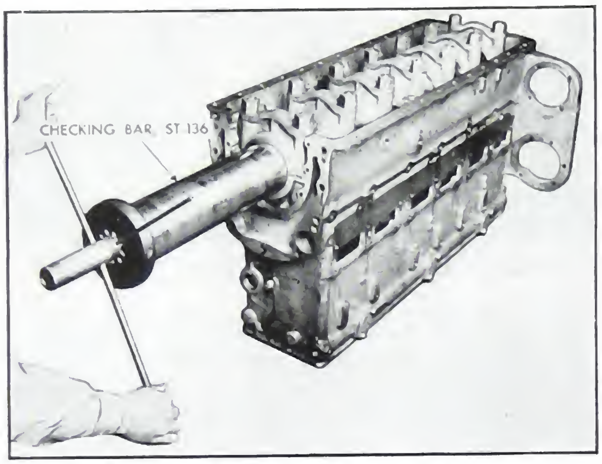


Fig. 2-6. Main bearing bore alignment

5. If it is definitely determined that a main bearing cap has been distorted and is preventing the checking bar from passing through, mark the block for reboring. Check after reboring.

WATER PASSAGES: 1. Check all water passages to make sure that cleaning has been complete and that passages are open. Metered passages should be cleaned with a drill of proper size to remove scale.

2. All NH and NHS cylinder blocks before Engine Serial No. 62907 should be equipped with water jets or drilled to direct water flow around the cylinder liners to improve circulation. Mark block for installation of jets if they are not present or in good condition. It is not necessary to install water jets in later style cylinder blocks which have water jets cast in the cylinder block.

CAMSHAFT BUSHINGS: 1. Camshaft bushings that are worn in excess of 2.0035 should be marked for replacement. Gauge with inside micrometers or dial bore gauge.

2. Check lubricating oil passages of camshaft bushings and block to see that passages are open.

3. Mark bushings for replacement if bearing metal has been chipped, badly scored, scratched or if it has been damaged by cleaning solution.

THREADS: 1. Mark studs and bolts for replacement if the threads are worn badly or, if they have been damaged. Poor stud threads can ruin a cylinder block.

2. Helicoil inserts can be used to repair oil pan threaded holes where threads have been stripped. Helicoil insert tool kits are available as service tools, ST-262, ST-263, ST-264, ST-265, ST-266 and ST-267. It is not practical to install helicoils for main bearing studs.

Cylinder Liners

CORROSION: Deeply pitted cylinder liners, 1/16" or more, should not be reused.

CRACKS: 1. Cracks in cylinder liners are most apt to occur (a) just under the top flange, (b) at the bottom of the liner or (c) above the top seal ring groove. These points should be checked very closely.

2. Magnetic inspection can be used successfully if the test is made by pouring the solution over the liner while it is actively magnetized. Cast iron is not adapted to a residual magnetic test.

3. A very practical method of checking cast iron for cracks is to: (a) clean the part thoroughly, (b) dip or paint with lubricating or fuel oil, (c) dry the part and (d) paint with chalk dust and alcohol or "whiting". The chalk will be discolored by any remaining oil seeping from the cracks or pores.

4. Only standard liners of latest approved type as shown in current parts book for the engine should be reused.

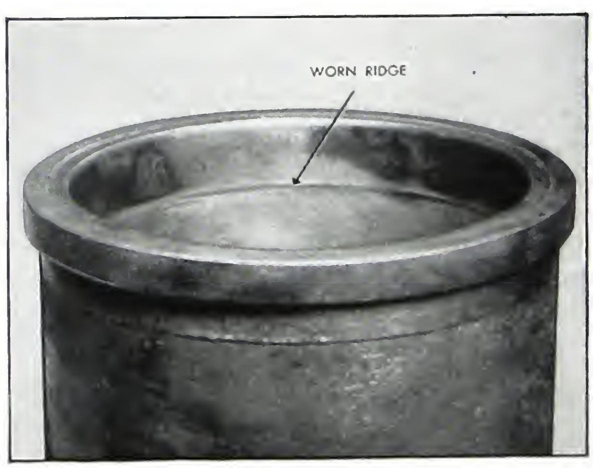


Fig. 2-7. Ridge in worn liner

CRANK-PIN OIL HOLES

DO NOT USE:

1. OPEN INDICATIONS INTERSECTING 45°±5° DIAGONAL CLOSER THAN 1/8 TO OIL HOLE OR ENTERING OIL HOLE CHAMFER.
2. SUBSURFACE INDICATIONS CLOSER THAN 1/32 TO SURFACE AT OIL HOLE AND INTERSECTING CHAMFER AT 45°±5° DIAGONAL. SEE NOTE ON REPAIR FOR PINS WITH SIDE DRILLING ONLY.—NEW STYLE.

MAIN BEARING OIL HOLES

DO NOT USE:

1. OPEN INDICATIONS OVER "E" INCHES LONG THAT ENTER THE CHAMFER.
2. SEE NOTE ON REPAIR.

NOTE: REPAIR OF OIL HOLE INDICATIONS

CHAMFER MAY BE OBLONGED 1/4 LONG BY 1/32 DEEP TO REMOVE OBJECTIONABLE PORTION OF INDICATIONS. REMAINING PORTION OF INDICATION SHALL NOT EXCEED LIMITS GIVEN. BLEND SMOOTHLY AND REMOVE ALL GRIND MARKS.

MAGNETIZATION

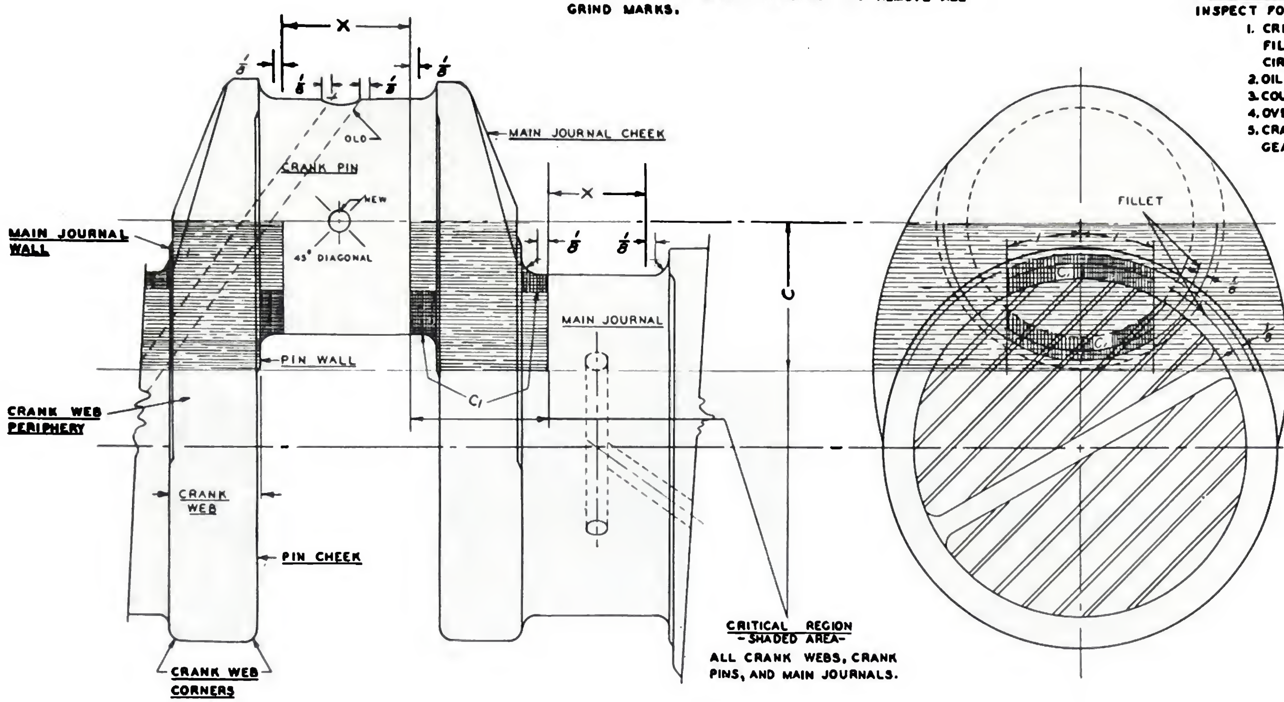
DIRECTION OF DEFECT →	LONGITUDINAL	CIRCUMFERENTIAL
AC EQUIPMENT	1400 AMPS	4200-4700 AMP-TURNS
DC OR RECTIFIED AC	1200 AMPS	3600-4000 AMP-TURNS
MAGNETIZING METHOD	HEAD SHOT	COIL SHOT

WET SURFACE BEFORE APPLYING CURRENT.

INSPECTION AT OVERHAUL OR BEFORE REGRIND

INSPECT FOR CRACKS OF SERVICE ORIGIN—CHECK:

1. CRITICAL REGIONS FOR CRACKS RADIATING FROM FILLETS ACROSS CHEEK OR PIN—TRANSVERSE OR CIRCUMFERENTIAL.
2. OIL HOLES FOR DIAGONAL CRACKS.
3. COUNTERWEIGHT WELDS FOR OPEN CRACKS.
4. OVERHEATED BEARINGS—DO NOT USE OR REGRIND.
5. CRACKS RADIATING FROM KEYWAYS AND FILLETS ON GEAR END.



INSPECTION OF REGROUND SHAFTS

INSPECT FOR CRACKS OF SERVICE ORIGIN IF HISTORY UNKNOWN, CRACKS DUE TO IMPROPER PROCESSING AND INCLUSIONS DETRIMENTAL TO USE—CHECK FOR:

1. GRINDING CRACKS ON BEARINGS AND WALLS—RANDOM.
2. STRAIGHTENING CRACKS—TRANSVERSE.
3. RADIAL CRACKS IN OIL HOLE CHAMFER.
4. HEAT CRACKS ON BEARINGS—LONGITUDINAL, DEEP AND EVENLY SPACED.
5. NON-METALLIC INCLUSIONS IN CRITICAL REGIONS, OIL HOLES AND ON BEARING SURFACES.

IDENTIFYING CHARACTERISTICS:

A. GENERALLY LONGITUDINAL—SLIGHTLY CURVED ON SIDES OF PINS—INCLINED ON 2, 3, 5 AND 6 MAIN JOURNALS.
B. USUALLY PARTLY SUBSURFACE OR SHOW EVIDENCE OF DEEPER LYING PORTIONS.
C. FINE IN CROSS SECTION WHEN INTERRUPTED BY MACHINED SURFACE.
D. FORM SMOOTH FLOWING LINES—NOT JAGGED OR IRREGULAR.

EVALUATION OF INDICATIONS:

1. DO NOT USE SHAFTS WITH CRACKS OF SERVICE ORIGIN OR PROCESSING CRACKS.
2. USE LIMITS SHOWN ON SKETCH FOR EVALUATING NON-METALLIC INDICATIONS. INCLUSIONS ACCEPTED FOR USE IN THE OIL HOLE OR CRITICAL REGIONS UNDER THESE LIMITS SHOULD BE RESTRICTED TO LIGHT STRINGERS AS IDENTIFIED BY THE ABOVE CHARACTERISTICS.

BEARING SURFACES

WITHIN REGION "X" DO NOT USE:

1. OPEN INDICATIONS MORE THAN "B" INCHES LONG ON MAIN JOURNALS OR "D" INCHES LONG ON CRANK PINS.
2. OPEN PARALLEL INDICATIONS THAT CONTAIN LOOSE OR FOREIGN PARTICLES.
3. MORE THAN "F" OPEN INDICATIONS OVER 3/16 LONG PER JOURNAL OR PIN.
4. STONE ACCEPTABLE OPEN INDICATIONS .002-.004 BELOW BEARING SURFACE.
5. JUDGE PARTLY OPEN INDICATIONS BY RESIDUAL METHOD, I.E.; WIPE OFF INDICATION AND REAPPLY BATH WITHOUT APPLYING CURRENT.

ENGINE MODEL	B	C	D	E	F
A & JS SERIES	3/4	1 9/16	5/8	1/4	3
H & NH SERIES	1 3/8	2	1 1/16	7/16	4
NVH & VT	1 3/8	2 5/16	1 1/16	7/16	4
L & LR	1 7/16	2 3/4	1 3/8	7/16	4
VL	1 7/16	3 1/8	1 3/8	7/16	4

CRITICAL REGIONS

WITHIN REGION C_1, DO NOT USE:

1. INDICATIONS OVER 3/16 LONG THAT ENTER FILLET.
2. INDICATIONS OVER 1/4 LONG AND CLOSER THAN 1/8 TO FILLET.

BEYOND REGION C_1 AND WITHIN REGION C, DO NOT USE:

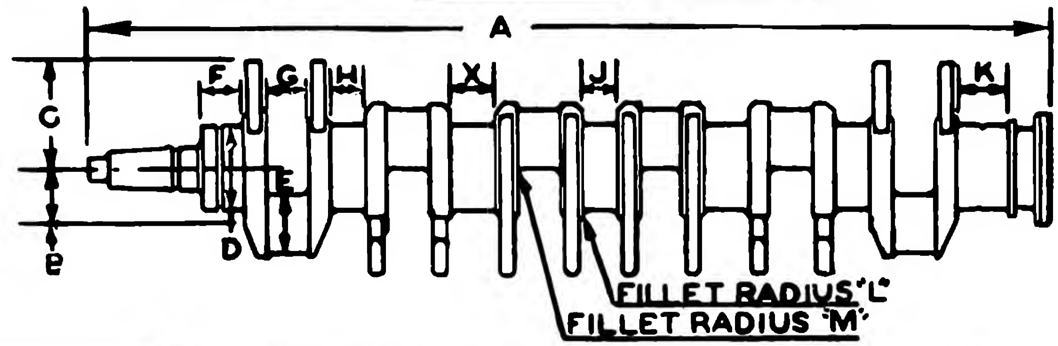
1. INDICATIONS OVER 1/4 LONG THAT ENTER FILLET.
2. OPEN INDICATIONS OVER 3/8 LONG AND CLOSER THAN 1/8 TO FILLET.
3. REMOVE AND BLEND NICKS ON CRANK WEB CORNER BY GRINDING 1/8 RADIUS ON CORNER.

SURFACE IMPERFECTION—INSPECTION & REPAIR METHODS—CUMMINS CRANKSHAFTS—		
CUMMINS ENGINE CO. COLUMBUS, INDIANA		
DATE: 1-11-54 DR. BY: SEM	CHECKED BY: ACH	SSK—31 DRAWING NO.

SEM	1-11-54	REVISED AND REDRAWN

Fig. 2-8. Magnetic inspection of Cummins crankshafts

CUMMINS CRANKSHAFT DIMENSIONS



ENGINE	PART No.	A	B	C	D	E	F	G	H	X	J	K	L	M
A-4	1741	29 5/8	2 1/2	4 1/2	3.874 3.875	2.624 2.625	1 15/32	2.000 2.003	1 7/16	1 7/16	1 7/16	1.434 1.437	.09375 .10175 R	.125 .133 R
A 6	1740	40 1/8	2 1/2	4 1/2	3.874 3.875	2.624 2.625	1 15/32	2.000 2.003	1 7/16	1 7/16	1 7/16	1.434 1.437	.09375 .10175 R	.125 .133 R
J S	10974	39.370 39.390	2.4975 2.5025	4 1/4	3.874 3.875	2.624 2.625	1 31/64	2.000 2.003	1.434 1.444	1.434 1.444	1.434 1.444	1.434 1.436	.141 .164 R	.141 .164 R
H-4 HR-4	1285-1	36 5/8	2.995 3.005	5 3/4	4.499 4.500	3.124 3.125	2 1/2	2.375 2.378	2	2 1/2	2	3.001 3.003	.1725 .1955 R	.1725 .1955 R
H-4 HR-4	5672-1	39 1/16	2.995 3.005	5 3/4	4.499 4.500	3.124 3.125	2 1/2	2.375 2.378	2	2 1/2	2	3.001 3.003	.1725 .1955 R	.1725 .1955 R
H-HR HRS	1282-1	50 1/2	2.995 3.005	5 3/4	4.499 4.500	3.124 3.125	2 7/16	2.375 2.378	2	2 1/2	2	3.001 3.003	.1725 .1955 R	.1725 .1955 R
H S	5671-1	52 15/16	2.995 3.005	5 3/4	4.499 4.500	3.124 3.125	2 7/16	2.375 2.378	2	2 1/2	2	3.001 3.003	.1725 .1955 R	.1725 .1955 R
N H	0123-1	52 15/16	2.995 3.005	5 9/16	4.499 4.500	3.124 3.125	2 7/16	2.375 2.378	2	2 1/2	2	3.001 3.003	.1725 .1955 R	.1725 .1955 R
HRBB NHRS	10846	52 15/16	2.995 3.005	5 3/4	4.499 4.500	3.124 3.125	2 7/16	2.375 2.378	2	2 1/2	2	3.001 3.003	.1725 .1955 R	.1725 .1955 R
NHH	43533	52 15/16	2.995 3.005	5 3/4	4.499 4.500	3.124 3.125	2 7/16	2.375 2.378	2	2 1/2	2	3.001 3.003	.1725 .1955 R	.1725 .1955 R
NVH VT	1830 0314	64 5/8	2.998 3.003	6	4.999 5.000	3.749 3.750	2 7/8	3.688 3.691	2	2	2 1/2	3.000 3.003	.1725 .1955 R	.1725 .1955 R
L	1190-4	86 9/16	4.995 5.005		5.499 5.500	4.249 4.250	4 11/16	3.625 3.628	3 1/4	3 1/4	3 1/4	5.250 5.253	.230 .260 R	.230 .260 R
L-LR	10863	86 9/16	4.995 5.005	8 3/32	5.499 5.500	4.249 4.250	4 11/16	3.625 3.628	3 1/4	3 1/4	3 1/4	5.250 5.253	.230 .260 R	.230 .260 R

Fig. 2-9. Cummins crankshaft dimensions

WORN LIMITS: 1. Cylinder liners should not be put back in the engine without reboring or regrinding if they are worn more than .004 in excess of new liner maximum diameter.

2. Worn liners that are to be used without grinding or boring and honing should be marked for ridge cutting or grinding to prevent damage to new rings. Fig. 2-7.

3. Rebored or reground liners should be machined to the nearest standard oversize. Pistons for oversize liners are available in .020, .030 and .040 oversizes.

4. New H cylinder liners are 4.876/4.877 diameter. New HR and NH cast iron liners are 5.1245/5.126 in diameter. Chrome-plated NH and HR liners are 5.125/5.128.

Crankshaft

JOURNALS: 1. Crankshafts should be reground, if main bearing or crank pin journals are worn or out-of-round more than .002.

2. Reground crankshafts should have the same fillet radii as new shafts. Smaller radii will weaken the shaft and larger radii will squeeze the bearings. See Fig. 2-9.

3. Crankshafts should be reground to standard undersizes. Undersize main bearings are available in –.010, –.020, –.030 and –.040 sizes. Undersize connecting rod bearings are available in –.010, –.020, –.030, –.040 sizes.

OIL PASSAGES: 1. Use a rod and rag, just as you would to clean a rifle barrel, to check and complete cleaning of oil passages in the crankshaft.

2. When pipe plugs are replaced, coat threads with John Crane Sealer and tighten to 5 foot-pounds. Pipe plug should then be staked to prevent loosening.

THRUST FLANGE: 1. Extreme wear of crankshaft thrust flange is generally caused by careless assembly of driven units.

2. If the thrust flange is worn more than .007, it should be ground for .010 oversize thrust half-rings or built up by electric arc welding and reground to specifications. Fig. 2-9.

MAGNETIC INSPECTION: 1. A great deal of trouble can be expected from *improperly* reground crankshafts. To avoid this trouble the shafts must receive proper magnetic inspection before and after reworking and specifications as to finish and dimensions must be closely followed.

2. Wet the entire surface with magnetic particle suspension before applying the current.

3. To detect longitudinal indications: Use 1200 amperes direct or rectified alternating current, or 1400 amperes alternating current, through the length of the shaft.

4. To detect circumferential indications: Use 3600/4000 ampere-turns direct or rectified alternating current, or 4200/4700 ampere-turns with alternating current. The part under examination must be two to three inches from the inside diameter of the coil or magnetizing surface.

5. Refer to Fig. 2-8. (Drawing SSK-31) for complete instructions.

FINISH: The finish of reground crankshafts should be comparable to that of new shafts. A poorly finished journal will quickly wear away bearing metal from shells.

DIMENSIONS: 1. Oil clearance is dependent upon (a) shell thickness, (b) main bearing or crankpin bore, (c) journal diameter and (d) alignment. All these dimensions must be within permissible tolerances.

2. Fillets add greatly to the strength of the crankshaft. Reducing fillet radii or undercutting subtracts materially from that strength. On the other hand, if fillets are larger than these specified, the bearing shells may be squeezed and fail very quickly.

NOTE: Current crankshafts have rolled fillets. These sometimes appear to be undercut; however, by close examination you can see where the metal has been "rolled" aside and not undercut.

3. New crankshaft dimensions are shown in table, Fig. 2-9. Reground shafts should have the same dimensions, after allowing for standard regrinds, as new shafts.

Camshaft

JOURNAL WEAR: 1. New camshaft journal diameters are 1.997 to 1.998. This allows for .0015 to .004 oil clearance between journal and bushing. Journals should not be worn smaller than 1.996 to be reused.

2. Injector lobe lift should be .1325/.1345.

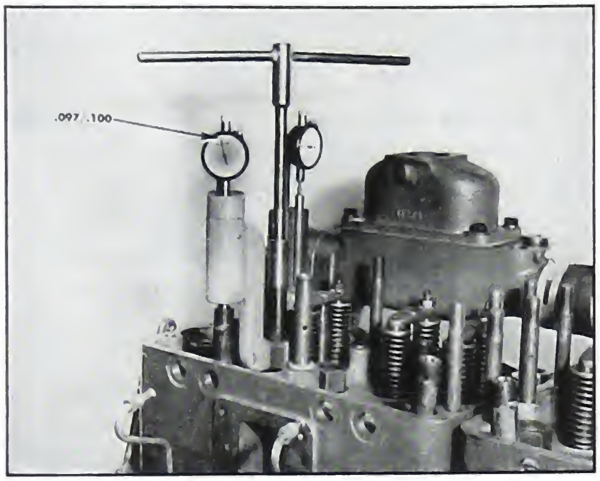


Fig. 2-10. Injector push rod travel

This can be measured as .097/.100 inch lift of the injector push rod in the engine. If measured in the engine, ST-300, Timing Fixture can be used. Refer to "Engine Timing" section. Total lift of injector push tube should not be less than .096 as measured with Fixture, ST-300, in the engine. See Fig. 2-10.

3. Camshafts can not be successfully reground.

4. Check to make sure that proper camshaft is used in engine.

5. Reject any camshaft with scuffed, scored or cracked injector or valve lobes.

6. Although broken camshafts are not likely to occur and are not as dangerous as broken crankshafts they should be checked by magnetic inspection.

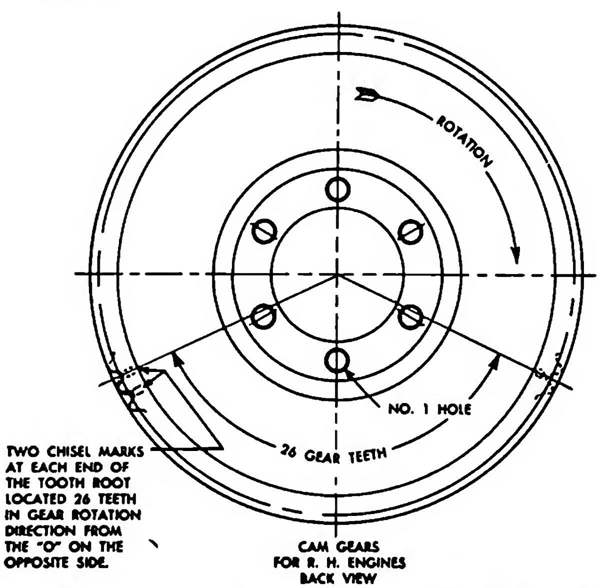


Fig. 2-11. New timing marks on right hand cam gear

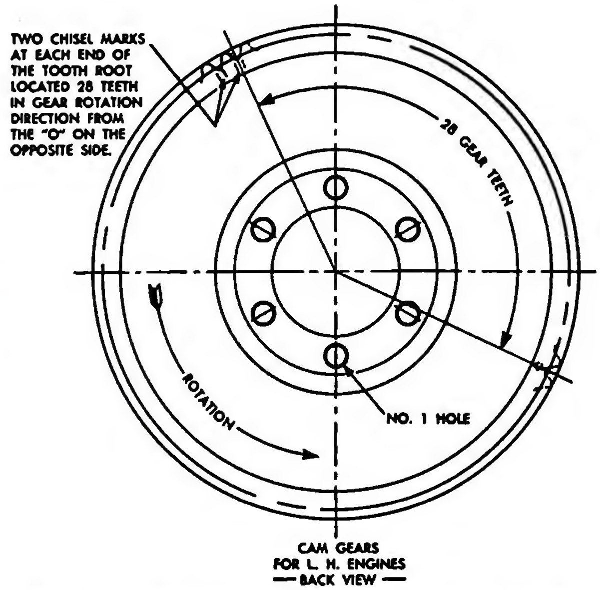


Fig. 2-12. New timing marks on left hand cam gear

TIMING MARKS ON CAM GEARS: 1. All cam gears have two timing marks: a "0" which indexes with the "0" of the crankshaft gear, and center punch, or dash marks, which index with the punch-marked tooth of the fuel pump or fuel pump drive gear. See Fig. 2-59 and Fig. 12-17.

2. Formerly, the punch marks were 35 to 37 teeth from the "0" mark, and all fuel pumps were installed at No. 1-6 Top Center position.

3. Beginning with Engine Serial No. 72125, the punch marks were changed to dash (—) marks and retarded 9 teeth. The dash marks are now located 26 teeth for right hand engines, or 28 teeth for left hand engines, from the "0" mark, and *in gear rotation direction.*

4. All H and NH cam gears are to be marked as shown in Fig. 2-11 or Fig. 2-12 regardless of the type fuel pump (single-disc or double-disc) used on the engine.

5. Check cam gear markings and, if the gear has the obsolete marking, remove the old center punch marks. Make new dash marks 9 teeth back of the marks removed to agree with current gear marks.

Connecting Rods And Pistons

CHECK ROD DIMENSIONS: 1. Assemble cap to rod and tighten down bolt nuts to operating tension by the template method as described on Page 2-12. Gauge, with bore gauge or inside micrometers, the crank pin bore. It should be 3.2722

to 3.2732 to provide correct bearing crush. Worn out-of-round limit should not exceed .002.

2. Gauge the piston pin bushing diameter with a dial bore gauge, or inside micrometers. The limits for a new bushing are 2.001/2.0015. Worn limit at any point should not exceed 2.0025.

3. A good checking fixture is essential to an intelligent inspection of connecting rods. Checking fixture, ST-227, is an accurate, easily-used fixture and the following instructions are given concerning its use.

4. Take a new rod which has been checked for absolute length. (Production rods may vary from 11.998 to 12.000 in length). Tighten bolts to hold cap to operating tension. Select a new piston pin that checks 1.999 outside diameter and insert in the rod.

5. Insert and tighten ("snug" only) the expanding arbor of ST-227 in the crank pin bore of the rod. The ball of the arbor must be assembled downward and on the center line of the rod. Set the rod in the fixture as illustrated and adjust both dial indicators to "0".

6. Lift the rod, arbor and pin assembly from the fixture, turn 180° and set back in the fixture.

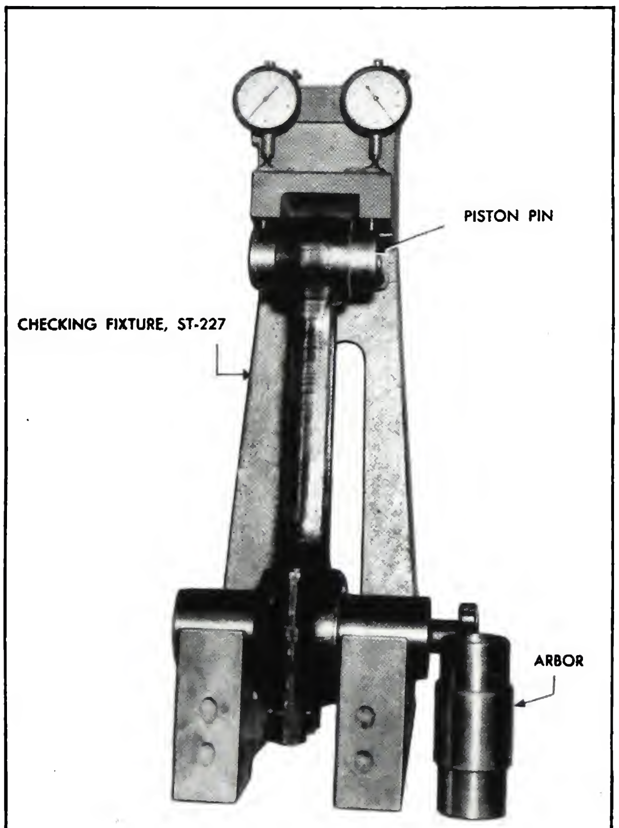


Fig. 2-13. Checking alignment of rod bores

7. Readjust the dial indicators to divide the difference between the first and second readings. The stop pins back of the piston pin are permanently located.

8. *The fixture is now adjusted for a perfect rod.* Measurements for all other rods can be read directly from dial indicators for length and misalignment of bores. As a double check, always turn the rod 180° after the first reading and compare with a second reading.

9. Use a feeler gauge between the piston pin and both stop pins to determine rod twist.

10. Twist must not exceed .010. Misalignment must not exceed .004 as shown by combined plus and minus readings of indicators. Length should be 11.998 to 12.000.

11. It is also possible that the center line of the rod may not be vertical to the bores, even though the bores are parallel. This can be checked by boring a 5/16" hole in the side of the fixture at the height of the piston pin center line and mounting a Starrett No. 196 indicator gauge so it will contact the milled surface of the rod at the piston pin end at the same time the milled surface of the large end contacts the finished surface of the fixture. The difference between two readings (after turning rod 180°) should not exceed .015.

12. The two step mandrel furnished with Fixture ST-227 can be used to check distortion of piston pin end of rod and length, misalignment and twist of an unbushed rod.

MAGNAFLUX CONNECTING RODS: 1. All connecting rods, caps and bolts should be magnafluxed and scrapped if they show any cracks.

2. Rods should be checked with 1000 amperes current longitudinally between plates, and at 3600 to 4000 ampere-turns in a coil. Pay particular attention to the shaded critical areas shown in Fig. 2-35.

3. A one-and-one-half percent wet solution should be applied while the current is ON, and separate visual inspection should be made after each application of current.

CONNECTING ROD BOLTS: 1. Check the connecting rod bolts just under the head for possible interference. The head of the bolt must rest

squarely on milled surface of the rod. The bolt fit in the rod varies from –.0005 to .0005 clearance.

2. If the connecting rod bolts have been tightened to excess they may be permanently stretched in which case they must be discarded. The smallest diameter of a new bolt is .541/.545. Never use an old bolt if the diameter at the smallest point is less than .540 unless there is an undersize stamp on the 45° surface of the head.

3. Discard all old bolts and nuts that have distorted threads.

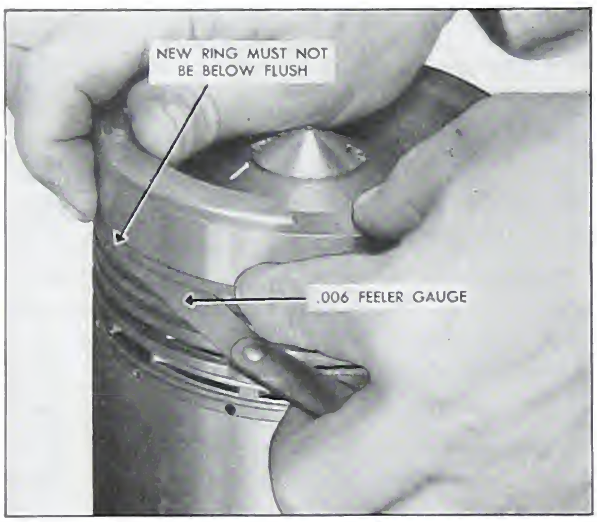


Fig. 2-14. Ring groove wear in piston

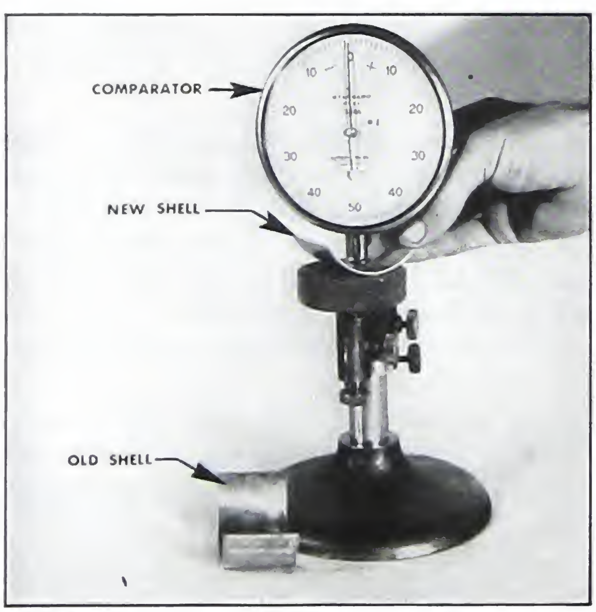


Fig. 2-15. Comparing thickness of new and worn shells

PISTONS: 1. Worn pistons should not be installed for another service period if the ring-to-groove side clearance is in excess of .006. Check as shown in Fig. 2-14. When a new wedge-type ring segment is pushed in the ring groove with a .006 feeler gauge, the outside surface of the ring segment must not go below the adjacent ring land face. Make sure that the feeler gauge is contacting *only* the worn portion of the ring groove.

2. When pistons are gauged for piston-liner clearance the reading must be taken at the skirt and at right angles to the piston pin hole. Pistons should never be used if worn more than .004 on this diameter. Gauging should be done at temperatures between 70° F. and 90° F.

3. Piston pin bore of aluminum pistons at 70°-90° F. should be 1.9987/1.9989. Cast iron piston pin bore is 1.9994/1.9996. Piston pins when new are 1.9990/1.9988.

4. See "Table—Piston Dimensions," Page 2-22 for additional data.

MAIN AND CONNECTING ROD BEARINGS: 1. Connecting rod shells and main bearing shells should be gauged for thickness with a comparator or with a ball point micrometer. Shells should not be reused if worn more than .002 in thickness, or if they are scored or damaged in any other way than by normal wear. See Fig. 2-15.

2. Total worn maximum oil clearance should not vary more than .002 between adjacent main bearings.

3. A properly fitted bearing, after a reasonable period of service, will show a dull gray or brown appearance indicating that the shaft has run on an oil film. Bright spots indicate lack of oil film and black spots excessive clearance.

CYLINDER LINERS: 1. Check worn cylinder liners with a dial bore gauge or inside micrometers. Liners should be replaced, or ground to nearest standard oversize, if they are worn more than .004 over high limit of new liner. This worn limit for standard size model H cylinder liners is 4.881 and for Model HR and NH, 5.130.

2. Cylinder liners need sand blasting or some similar type cleaning to remove all rust and scale. Acceptable liners should be protected by oil after cleaning.

3. Do not use any liners with signs of excessive outside corrosion (1/16″ pits or more), or inside

scoring, unless the score marks are removed by grinding to a standard oversize.

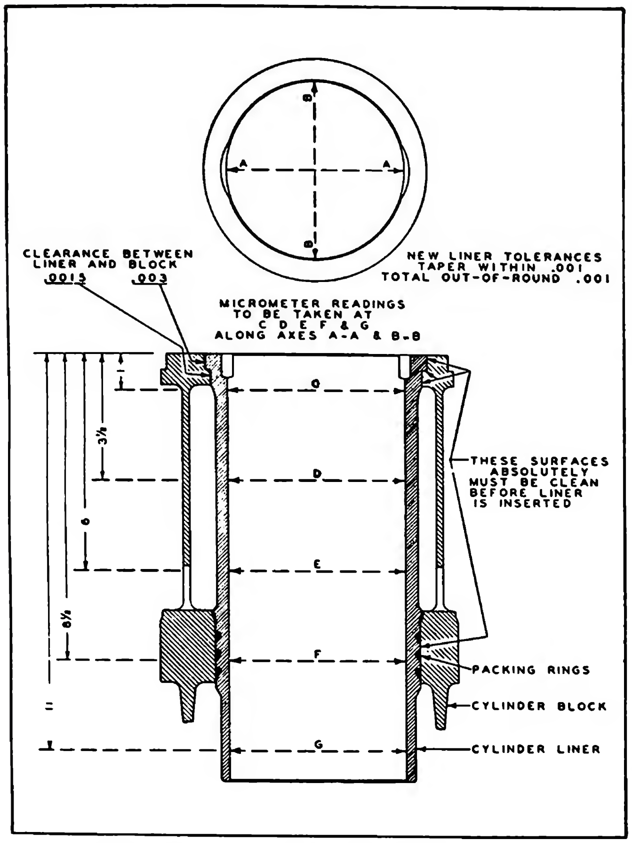


Fig. 2-16. Clyinder liner gauge marks

4. When liners are glazed the glaze can be removed as follows; however, after honing, liners should be checked to insure that they are still within limits and not oversize:
   a. Remove the top ridge with a ridge cutter.
   b. Use a dry stone Micro-Matic 3-15089 EE or the equivalent to remove the glaze. Keep the stones free from the glaze by using a wire brush.
   c. Hone to 45° angle pattern.
   d. Do not over-hone, stop when glaze is removed.
   e. Coat liner ID with lard and use stone Micro-Matic 37C500HV#22 or equivalent to get a new liner finish. Compare with new liner after cleaning.
   f. Use soap cleaning solution to clean liner.
   g. Check liner to see that it is not oversize. See steps 1 through 3 above.

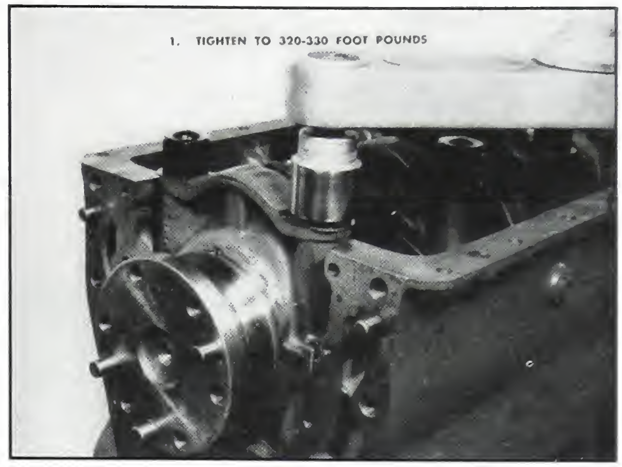


Fig. 2-17. First step in tightening main bearing nuts

Template Method Of Tightening Main And Connecting Rod Bearings

The template method should be used to tighten main and connecting rod bearings on Cummins engines. *It is important, in order to maintain a round hole, that the same method of tightening should be followed in service as that used when the bores were originally machined.* Main bearing bores in the cylinder block and the crankpin bore in the connecting rod are machined at the factory after the studs and bolts are tightened by the following described template method.

Template marks—50 degrees apart—were used on all H and NH main bearing caps between Engine Serial No. 45065 and engines with cylinder blocks dated after April, 1951. After the "April, 1951" dating, the marks on the caps are 30 degrees apart. The two markings can be identified easily because 50 degree marks are approximately 11/16 inch apart while the 30 degree marks are less than 7/16 inch apart.

MAIN BEARING STUD NUTS: Four steps are required to tighten H and NH main bearing stud nuts:

First Step—Initial Tightening: Provide new lockplates. Oil threads and lockplates. Tighten nuts to 320 foot-pounds with a torque wrench. See Fig. 2-17.

This is not operating tension: This step is used only to set bearing shells, caps and lockplates, and to squeeze oil film.

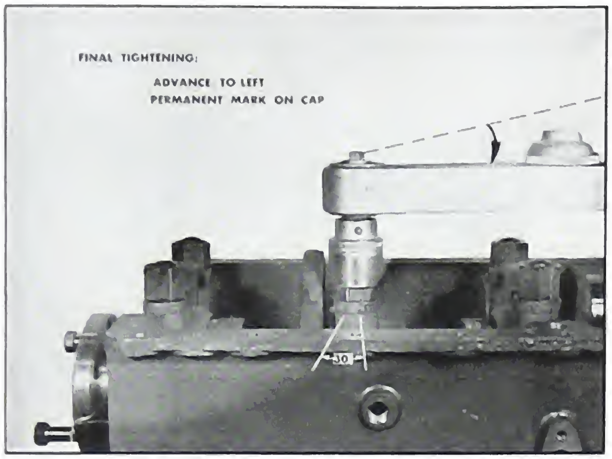


Fig. 2-18. Final tightening of main bearings—30° advance from snug position

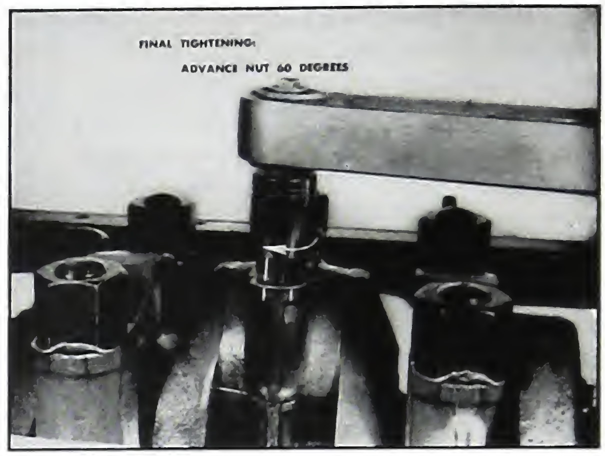


Fig. 2-19. Final tightening of connecting rod nuts—60° advance from snug position

Second Step—Loosen Completely: Back off nuts at least one full turn to release all tension.

Third Step—Snug Tighten: Retighten the nuts with an accurate torque wrench to 140 foot-pounds. This should be done in two or more steps to insure even tightening.

Fourth Step—Final Template Tightening: Advance nuts 30 degrees beyond the snug position described in third step. *This is operating tension.*

The 30 degrees advance can be determined by either of two methods:

A. If caps have the current 30 degree template markings, scribe a thin extension line from the first template marks to the nut, and advance the nut until the scribed line indexes with the second template mark, Fig. 2-18, or follow procedure in "B" below.

B. If caps do no have the current 30 degree template markings, scribe a line on the cap in line with one corner of the nut, and advance the nut one-half of one hex face. (This should be determined accurately by a scribed line down the middle of the nut hex face.)

CONNECTING ROD NUTS: Four steps are required to tighten H and NH connecting rod nuts:

First Step—Initial Tightening: Provide new lockplates, and oil the lockplates and threads. Tighten nuts to 140 foot-pounds with a torque wrench. *This is not operating tension.*

Second Step—Loosen Completely: Back off nuts at least one full turn to release all tension.

Third Step—Snug Tighten: Retighten the nuts with an accurate torque wrench to 50-55 foot-pounds. This should be done in two steps to insure even tightening.

Fourth Step—Final Template Tightening: Tighten each nut an additional 60 degrees. This is equivalent to advancing the nut one hex face beyond the position obtained in Step 3.

Caps have template marks 60 degrees apart. You can use the template marks and a pencil line on the nut, or make a pencil line on the cap in line with one corner of the nut, and advance the nut until the next corner lines up with the pencil mark.

TABLE—TEMPLATE TIGHTENING

	A. Tighten Ft. Lbs.	B. Loosen	C. Retighten Ft. Lbs.	D. Advance Degrees
Connecting Rods:				
H, NH	140	Loosen Completely	50/55	60°
Main Bearings:				
H, NH	320	Loosen Completely	140	30°

CRANKSHAFT END CLEARANCE: 1. Attach a dial indicator gauge securely to the cylinder block with the contact point of the gauge resting on the crankshaft flange end face.

2. With a small bar, pry the crankshaft toward the front of the engine. Remove the pry bar and set the gauge at "0".

3. Pry the crankshaft toward the rear of the engine and again remove the pry bar before reading the indicator. The gauge should indicate .007 to .013 end clearance. Make sure that there is no movement of the bearing shell.

4. If the end clearance is less than .007, it will be necessary to loosen the nuts slightly and shift the crankshaft first toward the front end of the engine and then toward the rear of the engine. If the nuts have been loosened, retighten as per Columns B and C.

NOTE: End clearance may be a minimum of .004 for two-piece rear main bearings.

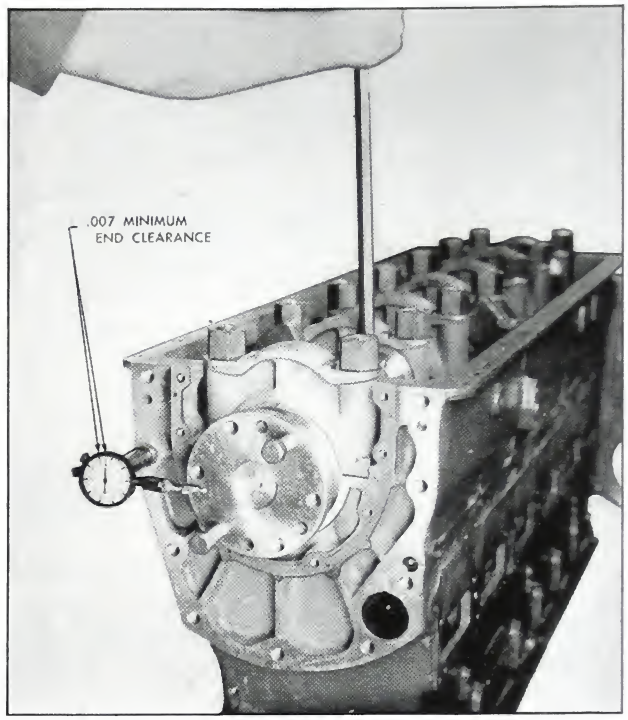


Fig. 2-20. Checking crankshaft end clearance

REBUILDING

Perform such of the following rebuild operations as inspection shows necessary.

Cylinder Block

CYLINDER LINER COUNTERBORE IN BLOCK: 1. The counterbore at the top of the cylinder block for the liner must be smooth, perpendicular to the bore and .435/.434 deep. When the cylinder liner is assembled in the block, the top of the liner must be .004 to .006 above the milled top of the cylinder block.

2. If the counterbore ledge is worn uneven from a fretting cylinder liner, it will be necessary to clean up with a boring bar or counter-bore tool. Use ST-395 for this operation.

3. If it is necessary to replace any cylinder head studs it must be done before the counterboring operation is performed. With ST-395 it is not necessary to remove any of the head studs.

4. The counterbore tool should be used as follows:

a. Position the tools' lower pilot in the packing ring area of the liner bore.

b. Set tool adjustable sleeve so the blades just touch the bottom of the counterbore ledge. Use lubricating oil on the cutter blades.

c. With even pressure turn tool in clockwise rotation until tool stops cutting.

CAUTION: NEVER TURN TOOL IN REVERSE ROTATION OR IT WILL DAMAGE THE CARBIDE CUTTER BLADES.

d. Check seat to determine if additional cuts are required.

e. Always use a series of light cuts to clean up entire circumference of the seat.

5. Use No. 42486, –A, –B or –C shims which are respectively .007, .008 or .009 thick to compensate for the metal removed by wear or by boring, and restore liner protrusion to .004/.006. Use as few shims as possible; i.e., use one thick shim in preference to two or more thinner shims.

MAIN BEARING STUDS: 1. Drilled main bearing studs are needed only for those engines not equipped with continuous groove upper main bearings. If the cylinder block is replaced new and if the block is not equipped with drilled main bearing studs and indexing drilled passages, be sure to install the increased-flow lubri-

cating system with grooved upper main bearing shells.

2. Do not remove main bearing studs from the cylinder block unless the studs are unfit for use. Due to the interference fit, removal of studs may ruin the block.

3. If studs are hand loose and can not be tightened to a minimum of 50 foot-pounds torque at a protruding height of 5¾″ to 5 21/32″, install new tighter fitting studs. Studs must protrude at least 5 21/32″ to avoid possibility of thread damage because of bottoming.

4. Cylinder blocks dated after "4-1-51" are tapped for tighter fit of main bearing studs. On these blocks, 75 to approximately 150 foot-pounds are required to set studs.

CAUTION: INSTALLING NEW STUDS OR TIGHTENING OLD STUDS MAY DISTORT THE MAIN BEARING BORE. ALWAYS CHECK MAIN BEARING BORE AFTER STUDS ARE CHANGED.

MAIN BEARING PILOT FIT: 1. The main bearing caps on engines after Serial No. 57715 have .002/.004 interference fit in the block. Before this serial number the caps may have as much as .001 clearance at this point.

2. A .0015 feeler gauge can be used to check these surfaces. If the feeler gauge will pass between the cap and the block at any point, when the cap is pulled to the snug position, the fault must be corrected or the block replaced.

REAM MAIN BEARING BORE: 1. Main bearing bores must be in alignment so that when the caps are tightened down by the template method the checking bar ST-136 will pass through all bores and turn by hand. The checking bar is 4.7472/4.7468 in diameter.

2. Main bearing bores must be 4.749/4.750 in diameter. They can be checked with properly set inside micrometers, or with a bore gauge set to a standard ring.

3. If inspection has definitely determined that the bores are out of alignment, the block may generally be salvaged by reaming with the special reamer, ST-172, as directed in succeeding paragraphs.

CAUTION: IT SHOULD NEVER BE NECESSARY TO REAM THE BLOCK UNLESS A BEARING CAP HAS BEEN DISTORTED. THIS TOOL SHOULD NOT BE USED INDISCRIMINATELY.

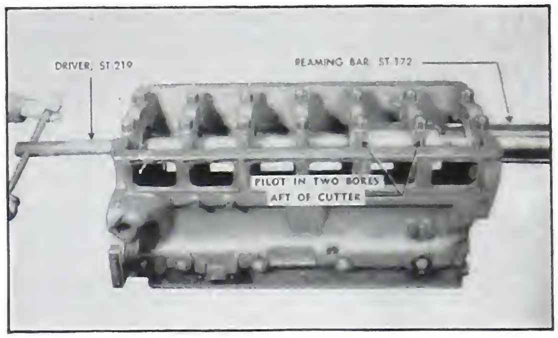


Fig. 2-21. Reaming main bearing bore

4. Remove, by lapping or surface grinding, .002 to .003 stock from the bottom milled surface of the main bearing cap/caps which is/are out of alignment.

5. Lay the reaming bar in the block so the rear end of the bar is piloted in two good main bearing bores.

6. Tighten all caps to operating tension by the template method as described on pages 2-11 and 2-12.

7. Lubricate liberally the cutters of the reamer and the bores in the block. This will prevent reaming oversize and will allow a better finish.

8. Use a special hand driver, ST-219, to turn the reamer. This driver is loosely pinned to prevent up and down or side thrust of the reamer while it is being turned. See Fig. 2-21.

9. Run the reamer through the remaining main bearing bores without "backing up" or reversing.

10. Check the block with ST-136 and, again, gauge the bore diameter.

REMOVE LINER-BLOCK INTERFERENCE: 1. Check the clearance between the cylinder liner and block before installing rubber rings. The liner should drop into place of its own weight.

2. Pass a .0015 feeler gauge around the entire circumference of the liner, between the flange and the block. (Fig. 2-22.)

3. If this .0015 clearance is not present, mark the binding spots with chalk. Then remove the liner and scrape the counterbore at the points of binding with a bearing scraper, until the proper clearance is obtained.

4. The liner must also fit freely in the block where the rubber pack rings fit against the block. This clearance can be checked for NH liners only by detectable "shake", but a .003 feeler gauge can

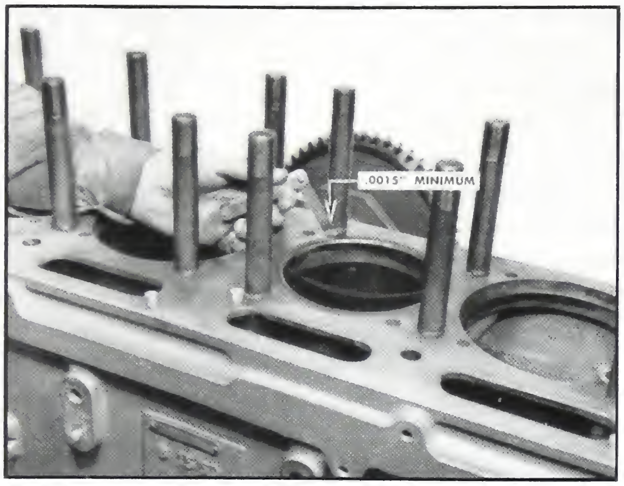


Fig. 2-22. Cylinder liner-block clearance "A"

be used to measure clearance between the block and Model H cylinder liners. If this clearance is not present at this point, it must be attained by scraping the block.

5. There must be at least .010 clearance at the closest point between the crankcase and the part of the cylinder liner that projects into the crankcase below packing rings. If the wall of the crankcase is closer than .010 to the liner at any point, obtain the clearance by grinding the block with a hand grinder. Fig. 2-24.

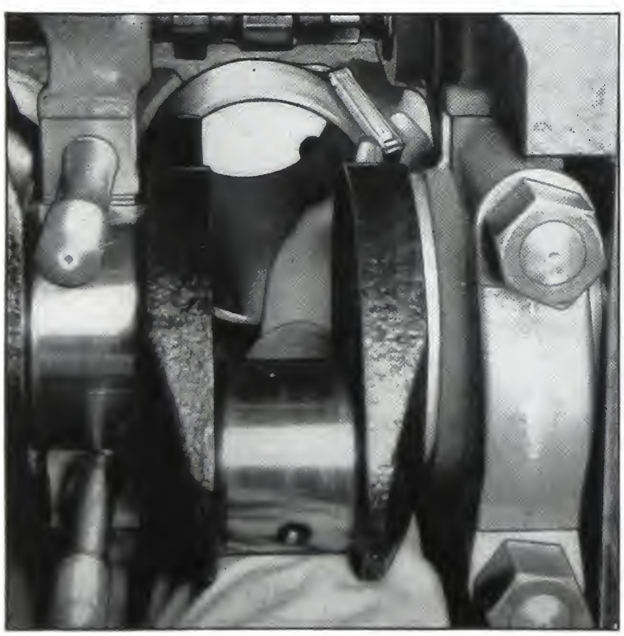


Fig. 2-23. Cylinder liner-block clearance "B"

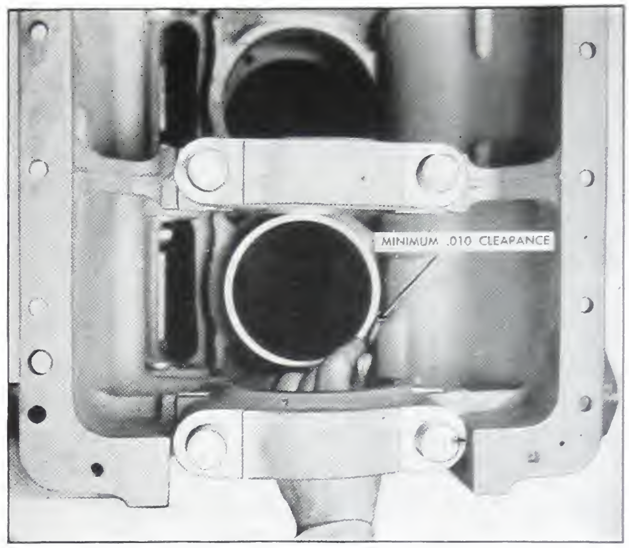


Fig. 2-24. Cylinder liner-block clearance "C"

REPLACE EXPANSION PLUGS WITH PIPE PLUGS: 1. Remove all expansion plugs from the cylinder block. If the block is one that has an expansion plug at the rear, two expansion plugs should be installed and locked in place with washers and cap screws as shown in sketch Figure 2-25.

2. If not already in use, $1\frac{1}{4}''$ pipe plugs should be installed in the water header in place of the expansion plugs. (Exception: If wall thickness is less than $\frac{1}{2}''$, expansion plugs must be used.) To install the pipe plugs it will be necessary to enlarge the hole with a $1\frac{1}{4}''$ American standard taper pipe reamer to the size of the plug counterbore and tap with a $1\frac{1}{4}''$ pipe tap deep enough so a $1\frac{1}{4}''$ countersunk pipe plug can be installed as shown in Fig. 2-26. A lead sealer should be used on the pipe plug threads.

3. All engines built since Serial No. 56591 have been equipped with pipe plugs or have cover

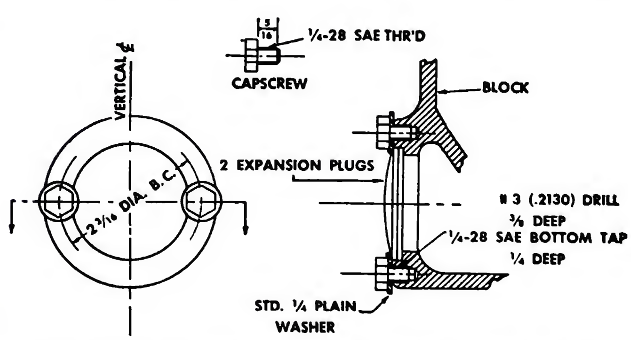


Fig. 2-25. Expansion plug locked in position in rear of block

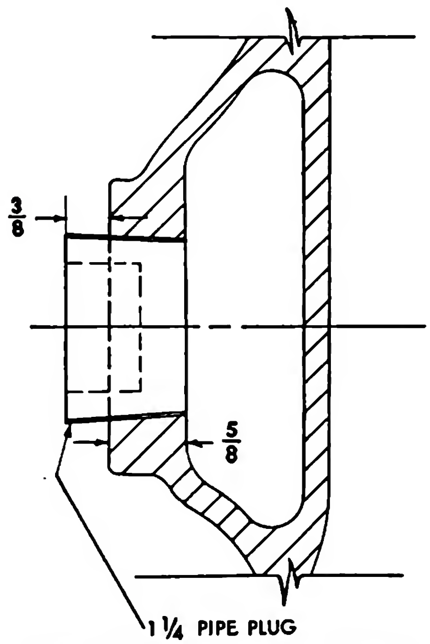


Fig. 2-26. Pipe plug installation

plates at the water header and at the rear of the cylinder block.

DOWEL REAR MAIN BEARING CAPS: To provide greater crankshaft thrust bearing life on the H, HS, NH and NHS engines the following procedure is recommended on engines previous to Serial No. 49143. Engines following this number have this feature incorporated.

1. Remove No. 7 main bearing cap from the block and grind or file flats on the cap at points A and B on the flywheel housing side of the cap as shown in Fig. 2-27.

Fig. 2-27. Drilling dowel hole

2. Set the cap flat on a drill press (milled side down) and use a 5/32" drill 7" long, to drill two holes through the cap as shown in Fig. 2-27. Chamfer holes slightly on the finished side of cap.

3. With the crankshaft and bearings out, assemble the No. 7 bearing cap on the studs. Pull the stud nuts down slightly against the main bearing nut lock plates so that the cap can be shifted. Using a straight edge, align the rear face of the cap on both sides with the machined surface of block where flywheel housing is bolted to the block as shown in Fig. 2-28. In some cases it may be necessary to scrape stud holes of cap to obtain correct alignment. If scraping is necessary, this should be done at the point where the cap pilots on the stud.

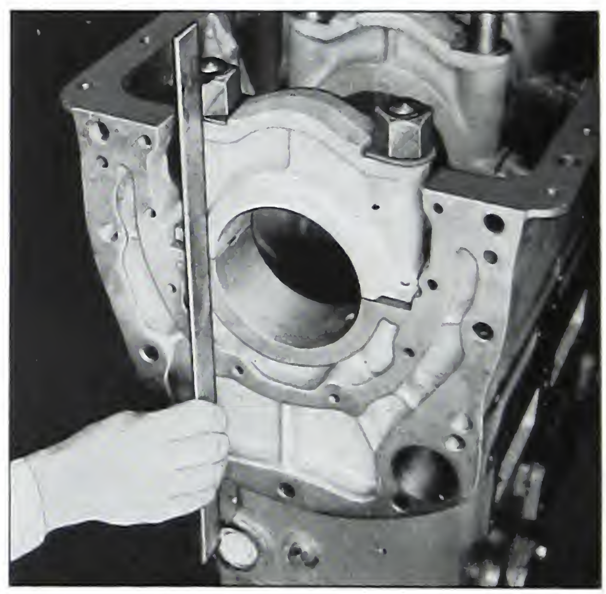


Fig. 2-28. Gauging alignment

4. Tighten the main bearing stud nuts as in final assembly and recheck the rear face of the bearing cap for alignment with the rear face of block on both sides.

5. Drill through the 5/32" holes in the cap with a No. 15 drill 3/8" deep into the cylinder block.

6. Ream the drilled holes in the cap and block to .1875.

7. Cut two dowels from 3/16" drill rod 1/16"

shorter than the depth of holes reamed in the cap and block.

8. Drive the 3/16″ dowels into the reamed holes to a definite stop and peen the metal of cap over the dowel as shown in Fig. 2-29 to eliminate any possibility of dowels dropping into oil pan.

9. Remove cap and reinstall crankshaft and main bearings.

10. Check end thrust clearance of crankshaft by mounting a dial indicator rigidly either on

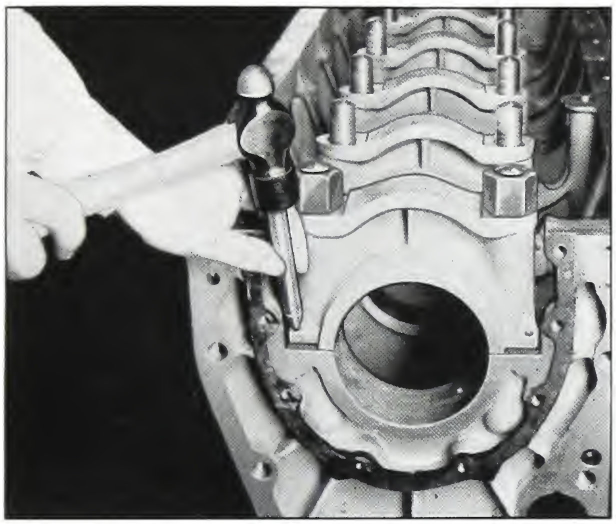


Fig. 2-29. Locking dowel in cap

the cylinder block, gear cover or flywheel housing allowing .020″ for indicator travel as shown in Fig. 2-20. Push crankshaft to rear position with a small pry bar and set indicator to "0". Then push crankshaft to the forward position. The indicator will then show the total end clearance of the crankshaft. This should not be less than .007 nor greater than .013 for new crankshaft and new bearings.

11. For worn or reground crankshafts and bearings that are being reused, the end clearance of crankshaft should not be greater than .022. Under such extreme conditions, bossing in piston must be closely checked during engine assembly.

See "Installing Crankshaft," Page 2-26, for instructions concerning use of oversize thrust half-rings during final assembly.

12. If .007 indicated end clearance is not present, bump the crankshaft with a wooden block or soft hammer to get the desired minimum clearance.

NOTE: End clearance may be a minimum of .004 for two-piece rear main bearings.

PROCEDURE TO INSTALL MAIN BEARINGS WITH REMOVABLE THRUST RINGS ON H AND NH ENGINES: Six-piece rear thrust bearings have been used on all NH engines since Serial No. 53367 and on H engines since Serial No. 56495. This combination consists of an upper and a lower shell and four thrust half-rings. To incorporate this change in engines made previous to the above serial numbers the main bearing caps must be reworked to install the dowels for the thrust rings as follows:

1. Remove the No. 7 main bearing cap from the block and clamp drill template ST-246 to cap with "C" clamp or drill vise. Drill one 19/64″ hole 13/32″ deep on each side of cap. Ream these holes to .3125, 13/32″ deep. Care should be taken in drilling and reaming these holes to prevent a run-out exceeding .005.

2. Press large end of shoulder dowels (Part No. 67294) into reamed holes of cap, making certain that the shoulder of the dowels are flush or slightly below the finished surface of the cap.

3. Check clearance between thrust rings and bearings by placing thrust rings on the cap and lay upper main bearing in cap. Repeat process using lower bearing. There should be at least .008

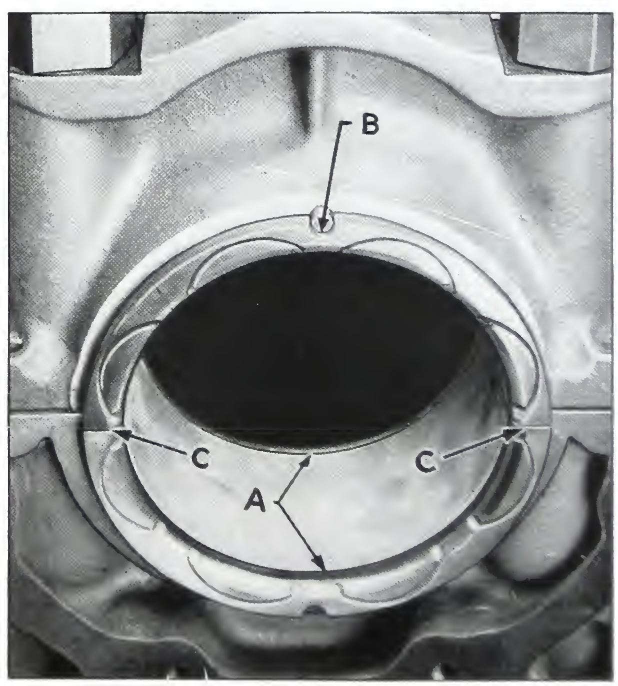


Fig. 2-30. Clearances between dowels and thrust rings

clearance between the bearings and the thrust ring at point "A", Fig. 2-30, when the thrust rings are held firmly against the block or cap.

4. To install bearings, lubricate all bearings with a coat of clean Lubriplate (high-pressure grease), roll in upper half of the bearings in the conventional manner. Push crankshaft toward flywheel end of the engine enough to permit the upper half of the rear thrust ring to be rolled into position. Push crankshaft forward until the thrust flange of shaft is seated firmly against the rear thrust ring and roll in the front thrust ring.

5. Install the lower rear thrust ring in position. Apply a small amount of Lubriplate to the thrust ring to hold it in position. Replace main bearing, front lower thrust ring, ring dowel and cap, being careful not to damage or distort thrust rings with the dowels in the cap.

Be sure that the No. 60575 main bearing dowel ring has not been omitted on No. 7 main bearing as the dowels in the bearing cap hold only the thrust rings in position.

6. Tighten main bearing stud nuts by the template method, Page 2-11.

7. Check clearance between dowel pins and thrust rings (point "B", Fig. 2-30). A clearance of .015 to .025 should be obtained between dowels

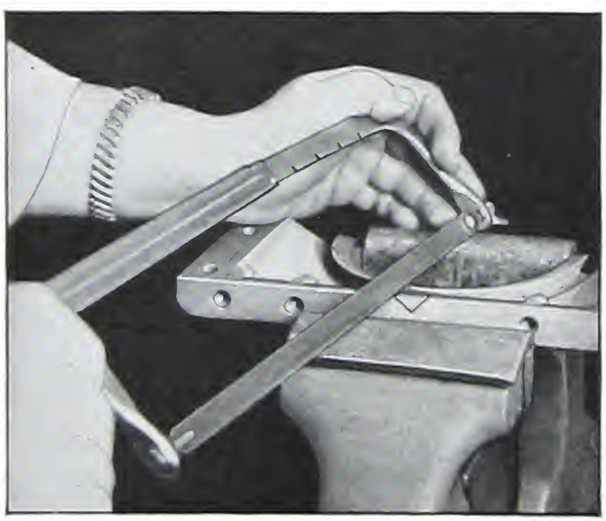


Fig. 2-31. Cutting dowel relief

and thrust rings. Check clearance at parting line (point "C", Fig. 2-30), of thrust rings. This should be from .020 to .040 when clearance is all taken at one side.

8. To permit removal and installation of main bearings in the future without removing the rear cover plate, a notch should be cut on the center line in the bottom edge of the rear cover plate (part No. 5080-4). It should be ⅝" wide at the base and 7/32" deep at the apex as shown in Fig. 2-31.

9. Using a 12" round file, file the notch until sharp edges and burrs are removed as shown in Fig. 2-32. Upon completion, the notch should be semi-circular and have a 5/16" radius.

CAUTION: THIS OPERATION SHOULD NOT BE PERFORMED WITHOUT FIXTURE ST-246.

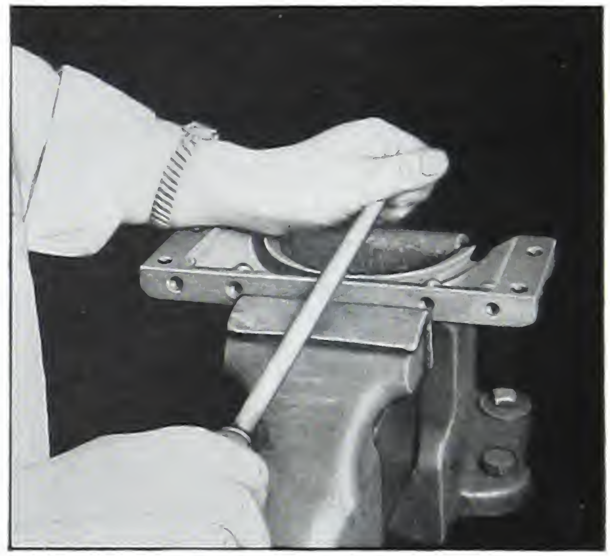


Fig. 2-32. Finishing relief

INSTALL CAMSHAFT BUSHINGS: 1. Driving mandrel ST-129 can be used to remove or install camshaft bushings. A guide block is furnished with this mandrel to bolt on the cylinder block in place of a cam follower housing. The guide will

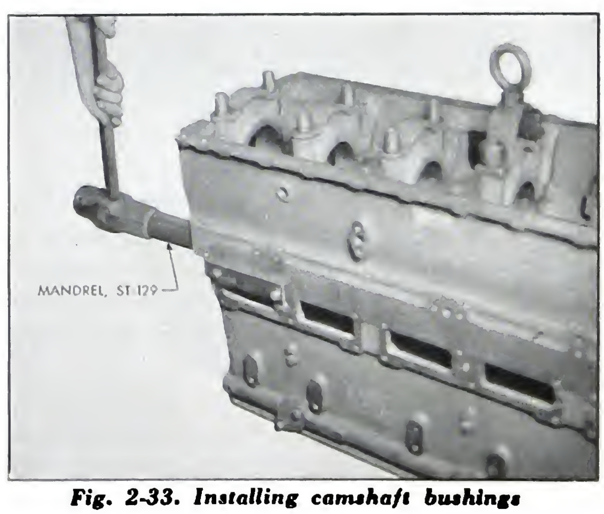


Fig. 2-33. Installing camshaft bushings

then support the mandrels while the bushings are being driven into place. The mandrels have locating holes to hold the camshaft bushings in position for alignment of oil holes. Short lengths of drill rod make good locating pins.

2. Locate the bushings on the mandrel and the mandrel on the guide block to install new camshaft bushings.

3. Check the oil passages to see that they are open.

NOTE: If preferred, a puller can be used satisfactorily for this operation.

OIL LINE PLUGS: After determining that the oil passages are open and clean, install the oil plugs and tighten.

PAINT CYLINDER BLOCK: 1. Paint the inside of the cylinder block with Sherwin-Williams No. 29064 Red Oxide Sealer.

2. Paint the outside of the cylinder block with Sherwin-Williams No. F62YC1 yellow engine paint.

Cylinder Liners

GRIND CYLINDER LINERS: 1. Model H and NH pistons and rings are available in standard, .010, .020, .030 and .040 oversizes. When cylinder liners are reground it must be to the next standard oversize.

2. Inside diameters of standard liners are as follows:

Liner	Min. I.D.	Max. I.D.
For Model H Series Engine	4.876	4.877
For Model NH Series Engine	5.125	5.128

Add oversize to standard dimensions for regrinding.

3. Use inside micrometers or dial bore gauge to check dimensions.

4. Cast iron cylinder liners can be bored with a Van Norman No. 777-4 cylinder boring bar (or equivalent) and finished honed to size. However, hard or chrome plated liners must be ground to oversize, if worn beyond usable limits. Grinding will remove all chrome plate.

5. If worn cylinder liners are to be fitted with chrome plated top rings, they must be roughened with a hone to enable the rings to seat.

CAUTION: CHROME PLATED RINGS MUST NOT BE USED WITH CHROME PLATED LINERS.

6. Remove the ridge at the top of worn liners with a ridge cutter, or other means, to prevent damage to new rings.

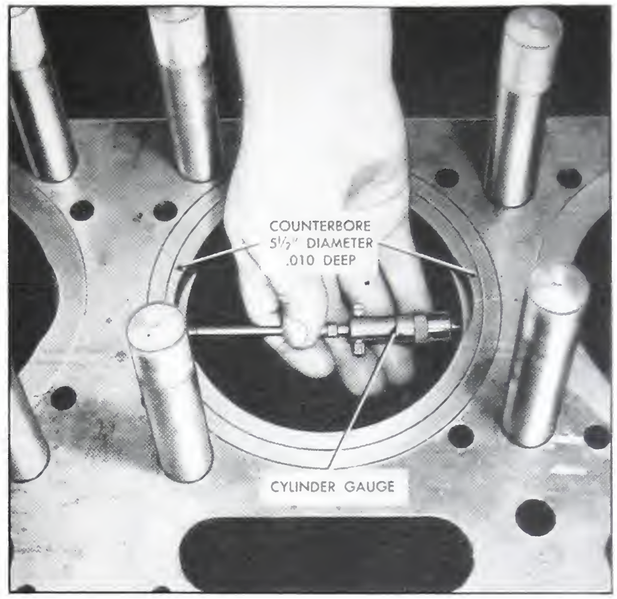


Fig. 2-34. Counterbore in cylinder liner

Crankshaft

GRIND CRANKSHAFT: 1. After inspection has determined that the crankshaft is worn to the point where it must be reground and magnetic inspection has shown that the crankshaft is suitable for regrinding, grind the shaft to the next standard undersize.

2. Connecting rod and main bearing shells used on H and NH engines are available in standard, .010, .020, .030 and .040 undersizes.

3. If the crankshaft thrust flange is worn more than .007, it should be ground smooth provided the use of .010 oversize thrust half-rings will bring end clearance within a total of .015″. If grinding increases end clearance beyond this point, the flange must be built up by welding and ground to standard "K" dimension as shown in Fig. 2-9.

4. Regrind the crankshaft to the next standard undersize and hold to specifications in the table "Cummins Crankshaft Dimensions", Fig. 2-9.

CRANKSHAFT GEAR: 1. If it is necessary to remove the crankshaft gear: Attach a puller to the gear and shaft and apply 75 to 100 foot-pounds tension on the puller screw. Heat the gear with a blow torch—*not* a cutting torch—to 300° F. to 400° F. The heat will expand the gear and make it pull easier.

2. To assemble a gear: Heat the gear to 400° F. and drive on with a piece of tubing.

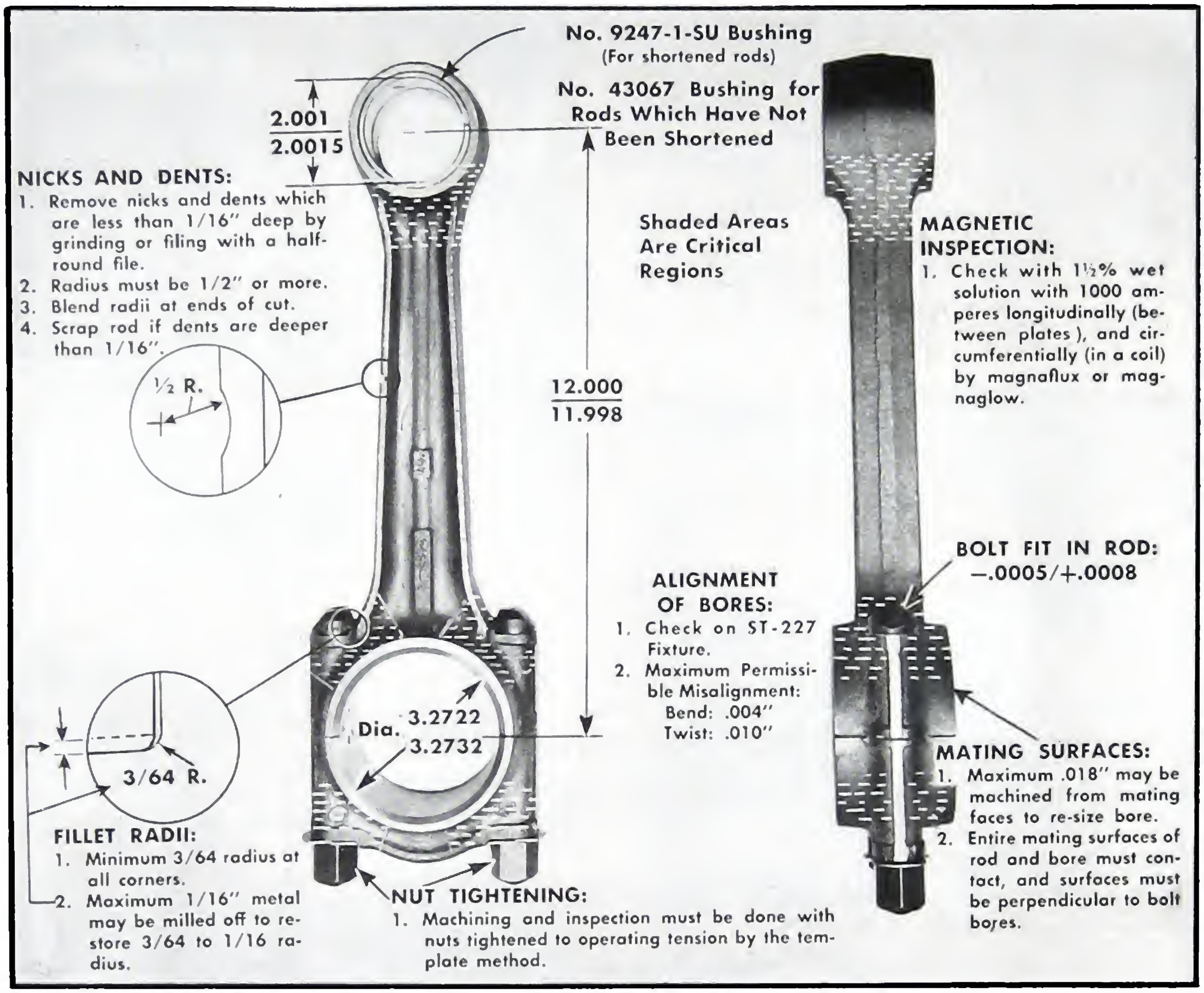


Fig. 2-35. Connecting rod specifications

Connecting Rods And Pistons

CRANK PIN BORES: 1. The crank pin bore diameter of the connecting rod is 3.2722/3.2732 when new.

2. After the connecting rod cap has been tightened down to the rod by the template method and if the crank pin bore is more than .002 out-of-round, oversize or undersize, it can not be used unless reconditioned as described in following text.

Resizing Crankpin Bore: If the crankpin bore does not check within the specified limits it must be resized to salvage the rod. The rod length must then be restored to 12.000/11.998 center-to-center to provide proper engine compression. A good machinist and special equipment are essential.

Field experience has shown that satisfactory service can be expected from connecting rods which have been reconditioned—including resizing of crankpin bore—if all inspection and machining operations are performed properly. The responsibility for the work must be assumed by the Owner or by the shop which does the work.

1. Remove old piston pin bushing with arbor press and ST-248 mandrel and block, Fig. 2-36. Install cap and tighten nuts by the template method. Recheck the rod length on ST-227 checking fixture. If rod has been resized previously, it will be shorter than standard by .018" or more and can not be resized a second time.

2. If rod is suitable for resizing crankpin bore: Remove cap and surface grind or mill .018" stock from mating faces of rod and cap. A fixture is

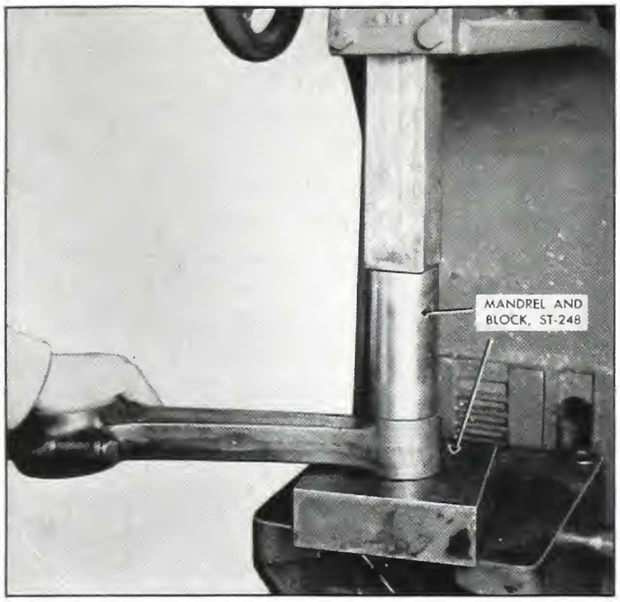


Fig. 2-36. Pressing in new bushing

required for this operation to insure that entire mating surfaces will contact after reassembly and that bores for bolts will be straight. Bolt holes must be vertical to machined mating faces.

3. Reassemble cap to rod and tighten to operating tension by the template method. *This is important!*

4. Line bore or grind the crankpin bore to 3.2722/3.2732. A fixture is required to insure alignment of bores within .004 inch total runout as measured by ST-227 checking fixture. Tool or grinding wheel must be centered accurately in old bore to insure cleaning up at 3.2722/3.2732 diameter. Finish surface should check at 40 micro-inch or better to insure proper contact with connecting rod bearing shells.

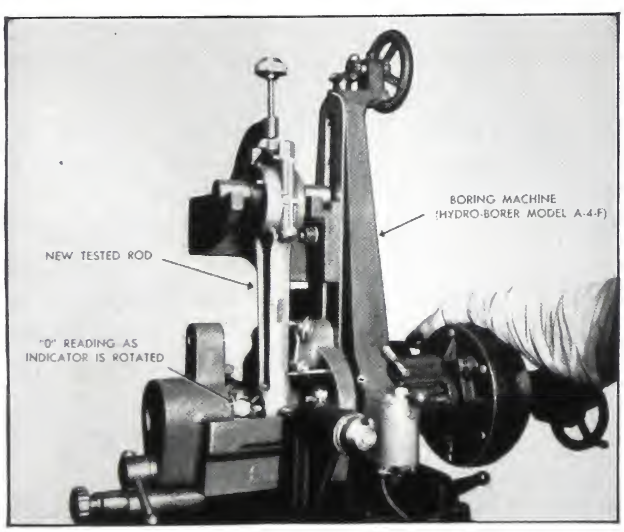


Fig. 2-37. Checking set-up with new rod

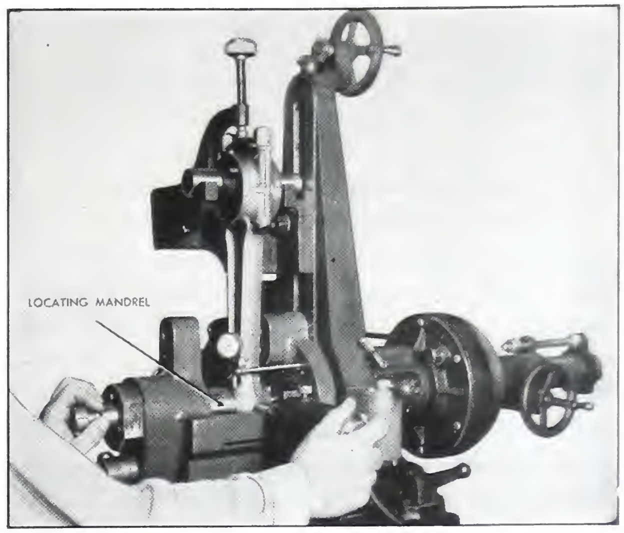


Fig. 2-38. Securing rod in boring machine

NOTE: ST-294 Boring Machine is not suitable for this job. A milling machine, heavy-duty boring machine or Heald cylinder grinder can be used satisfactorily with a precision fixture.

ROD FILLET RADII, NICKS AND DENTS: 1. A minimum 3/64" fillet must be present at all corners where the rod and cap are milled for the bolt heads and lockplates. A sharp corner at these spots will contribute toward rod breakage.

2. If the fillets have been removed by filing, they can be restored by milling off an additional 1/16" maximum metal to restore the fillet as shown in Fig. 2-35.

3. Sharp nicks or dents can contribute to rod breakage. Remove dents which are less than 1/16" deep by grinding with a one-half inch radius wheel or by filing with a half-round file. See sketch, Fig. 2-35.

PISTON PIN BUSHING: 1. After the connecting rod has been completely checked and all other reconditioning operations performed as needed, use ST-248 mandrel and block in an arbor press to press out the old piston pin bushing if not already removed.

2. Two piston pin bushings are available for the No. 2457-2 connecting rod:

A. Bushing 43067 is two-piece, split-type, steel-backed with approximately .015 boring stock, and it is recommended for all rods which have not been shortened by

resizing the crankpin bore. This bushing requires boring equipment.

B. Bushing 9247-1-SU is a special service bushing with .045 to .050 boring stock and it is supplied for rods which have been shortened by resizing the crankpin bore.

3. Using ST-248 fixture, press in the new bushing. Splits of the No. 43067 bushing should be staggered 45 degrees from the center line at the top of the pin hole, and the oil grooves lead from the space between bushing halves. If No. 9247-1-SU bushing is used, install with one groove located toward the bottom of the rod.

4. Fill bushing lubricating holes with soap to keep shavings out of oil passages.

5. Assemble the connecting rod on a line boring machine. The machine should be fitted with a dial indicator gauge in contact with the side of the connecting rod to detect any distortion of the rod while the rod is being tightened in the machine.

6. Bore the piston pin bushing to 2.001/2.0015. Check the size with plug gauge, ST-205. ST-205 is a two-step "GO", "NO GO" gauge.

7. Remove sharp edges from around oil grooves with a scraper.

8. Check rebushed and rebored rods on ST-227 as instructed on Page 2-9.

PISTON: 1. Reboring of piston pin holes and use of oversize pins is not practical because the misalignment that results from such practice will cause seizure of piston or failure of connecting rod bearings.

2. Injector cup wipers, or sneezers, were used in all Cummins pistons prior to Serial No. 88098. After this number, new aluminum pistons do not have the sneezer. Pistons with and without sneezers must not be mixed in any engine.

3. The sneezer, if used, must be installed and locked with lock plate No. 60026. If the sneezer comes loose during engine operation, it will cause extensive damage.

TABLE—PISTON DIMENSIONS

PART OR LOCATION		NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
Ring Groove Clearance		.002	.0045	.006
Piston Skirt Diameter (at 70°F)				
Part No.	Material			
2770-1	Cast Iron	4.8695	4.870	4.8655
2770-2	Cast Iron	4.871	4.872	4.867
3719, 3722	Aluminum	4.869	4.870	4.865
20514, 20530*	Aluminum	4.8675	4.868	4.8635
20737	Cast Iron	5.1195	5.1205	5.1155
20667-1, 21122, 20693, 21740, 21739, 21170, 20176, 20231-2, 21736, 21738, 21115, 20983, 21736	Aluminum	5.1165	5.1170	5.1125
20725, 20982, 21582, 21581, 21584, 21583	Aluminum	5.1145	5.1150	5.1105
21591*	Aluminum	4.8655	4.866	4.8615
Ring Gaps (with new liners): O.W. indicates overwidth rings				
4⅞ Compression: 42330, 43421, 43906 O.W., 43914 O.W.				.013/.032
65327				.010/.025
65354, 69602 O.W.				.010/.020
Oil Control: 65325, 65326, 42331				.010/.018
5⅛ Compression: 41878				.013/.023
42360, 43905 O.W.				.015/.025
Oil Control: 42035				.013/.023
Piston Pin Bore (at 80° F.)				
Aluminum Pistons		1.9987	1.9989	2.000
Cast Iron Pistons		1.9994	1.9996	2.0005

* These pistons for HS engines only.

TABLE—OVER WIDTH GROOVE SPECIFICATIONS

PISTON PART NO.	Original Groove Dimension "A"	Over Width Groove "B"	Degree of Taper "C"
20176-2, 20231-2, 20667-1	5/32	.1865/.1885	20°
20693, 20725, 20982	5/32	.1865/.1885	20°
20983, 21584, 21115	5/32	.1865/.1885	20°
21122, 21582, 21170	5/32	.1865/.1885	20°
21583, 20530, 21591	5/32	.1865/.1885	20°
3719-1, 3722	.1235/.124	.1545/.1555	15°

Note: See Fig. 2-39 for "A", "B", "C".

REGROOVING TOP RING GROOVE: 1. On aluminum pistons where the piston checks within limits except for a worn top ring groove, the groove can be machined to use an over-width ring.

2. To obtain satisfactory results from regrooving ring grooves the following precautions must be observed:

a. Piston must be held securely but so no machined surfaces are damaged or distorted. Bottom of groove to be cleaned up only machine from top.

b. Surfaces to be machined must be held within .0015 total indicated runout.

c. The limits given must be held accurately to obtain good ring seats. See the table "Over-Width Groove Specifications."

d. The crown of the piston should be stamped "OW" following the part number so the future mechanics will know the overwidth rings are to be installed.

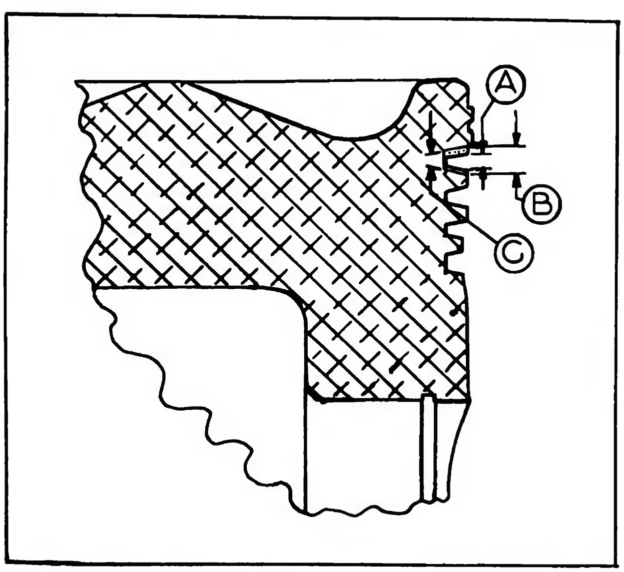


Fig. 2-39. Machining dimensions—overwidth grooves

ASSEMBLE RODS AND PISTONS: 1. Piston weight is stamped on the head of the piston. Piston size, also stamped on the head of the piston, must correspond with oversize cylinder liners when used.

2. Piston diameter must be checked at the skirt and at right angle to pin bore or as per the preceding table "Piston Dimensions".

3. Piston pins should fit in cast-iron pistons with .0005/.0007 clearance, or a thumb-push fit. It will be necessary to heat aluminum pistons in hot water to 170°/180° F. to install piston pins, because the fit of piston pin in aluminum piston at 70° to 90° F. is from .0001 to -.0003. Lock the pins in place with the snap rings at each end.

4. Do not use thin-walled piston pins on NH series engines.

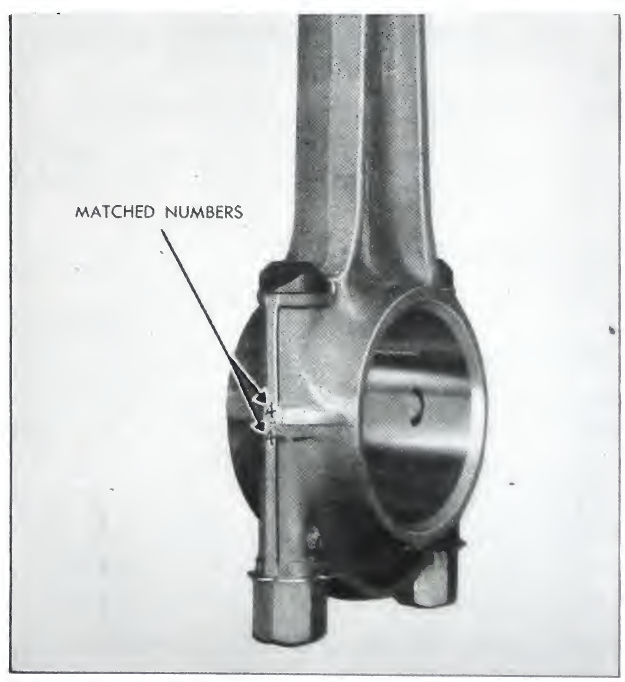


Fig. 2-40. Numbers on connecting rod

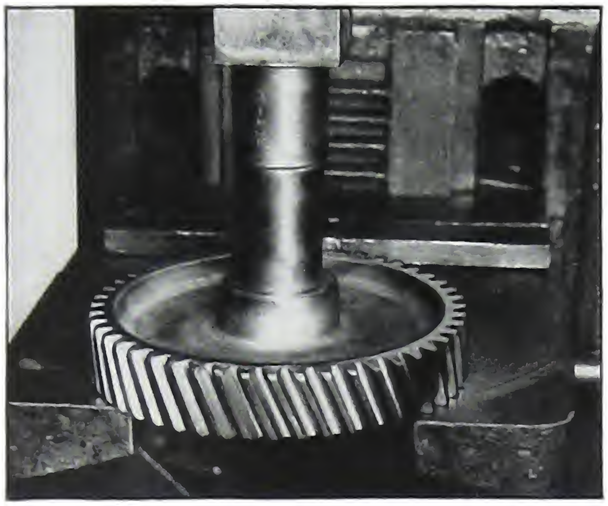


Fig. 2-41. Pressing new bushing in idler gear

CAUTION: NEVER DRIVE PISTON PINS IN PISTONS. DRIVING MAY CAUSE DISTORTION OF THE PISTON SUFFICIENT TO CAUSE SEIZURE OF THE PISTON IN THE CYLINDER LINER.

MATCH PISTON AND ROD ASSEMBLIES BY WEIGHTS: 1. Piston and rod assembly should not vary more than .75 ounce in weight from heaviest to lightest in any engine. Use a good set of balance scales to weigh the assemblies.

2. Group the assemblies by matched weights.

3. Stamp rod numbers on the rod and cap (if not already stamped) as shown in Fig. 2-40 from "1" to "6" for six cylinder engines.

Idler Gear

BUSHING: 1. If the idler gear bushing, No. 9224, is worn to more than 1.377 in diameter it must be replaced.

2. Use driving mandrel, ST-234, to press out the old bushing and to press in the new bushing. See Fig. 2-41.

3. Center the idler gear against the face plate in a lathe or in a fixture of a boring machine and bore the new bushing concentric with the gear outer diameter to 1.375.

4. On NHS and NHRS engines, check the idler gear ball bearing S-16090. Replace the bearing, if it is worn or rough.

REPLACE IDLER GEAR PIN: Check the idler gear pin, No. 9222. If it is worn smaller than 1.371, pull it from the block and drive in a new pin.

CAMSHAFT AND GEAR: 1. Assemble the gear to the camshaft indexing the "1" of the gear to the "1" of the camshaft flange.

2. Check to see that camshaft flange has no burrs. Chamfer, if necessary.

GEAR CASE COVER: 1. Knock out old oil seals and replace with new ones.

2. Check all ball bearings in NH and NHS gear case covers and replace, if worn or rough.

ASSEMBLY

Cylinder Liners

ENGINE STAND: 1. Secure the cylinder block to an engine stand. ST-255 is an engine stand that takes up very little working space in the shop when it is not being used.

2. The block is held to this stand at pads on the exhaust manifold side. The worm gear has a 48-1 ratio so that the engine can be turned completely end-over-end easily. All units with the exception of the supercharger, exhaust manifold and oil cooler can be assembled to the cylinder block on the stand.

CYLINDER LINER TO BLOCK CLEARANCES: 1. Install cylinder liners. Several types of failures can result when liners have been improperly installed, most serious of which would be scored liners and seized pistons. The following instructions should be carefully followed.

2. Make sure that all machined mating surfaces of liner and block have been thoroughly cleaned. If any dirt or scale is present on these surfaces, it will cause distortion of the liners and will result in failure.

3. Place the liner, without packing rings, into the block. It should drop into position of its own

weight.

4. Pass a .0015 feeler gauge around the entire circumference between the flange and block. (Fig. 2-22).

5. If this .0015 clearance is not present, mark the binding spot with chalk. Remove the liner and scrape the counterbore at points of binding until the proper clearance is obtained.

6. The counterbore at the top of the cylinder block for the liner must be smooth, perpendicular to the bore, and .435/.434 deep. When the cylinder liner is assembled in the block, with necessary liner shims in place, the top of the liner must be .004 to .006 above the milled top of the cylinder block. Check the cylinder liner flange with micrometers and compare with counterbore in the block to make sure that with the shims you have .004 to .006 protrusion. (Fig. 2-42).

7. The liner must always seat freely in the block at the point where the rubber packing rings fit against the block. Insert the liner without the packing rings and check at this point by the method previously described using a .003 feeler gauge. If .003 clearance is not present around the entire circumference, scrape the block at the binding point. See Fig. 2-23.

NOTE: The .003 clearance can not be measured on NH liners due to the flange. NH cylinder block—cylinder liner clearance can be detected only by "shake".

ASSEMBLY IN BLOCK: 1. Remove the liner. Assemble the rubber packing rings, being careful not to stretch them. Cylinder liner packing rings used on 5⅛" bore liners are ⅛" in diameter. Those used on 4⅞" liners are 3/16" diameter. Roll each liner ring into position, taking care to avoid stretching the ring.

2. Lubricate the packing rings and the machined portions of the block on which the rings seat with clean lubricating oil or ball bearing grease.

CAUTION: NEVER USE WHITE LEAD OR ANY LUBRICANT OTHER THAN LUBRICATING OIL OR BALL BEARING GREASE.

3. Assemble the proper amount of shims around the liner and push it into place with hand pressure only. Check the liner bore crosswise and endwise of the engine at various points within the range of piston travel. (Fig. 2-43). New 4⅞" liners are 4.877/4.876 I.D. New 5⅛" liners are—dependent on the type—5.125/5.128 I.D. If liners are more than .001 out-of-round, it will be necessary to pull the liner and check for a possible binding condition which would cause distortion of the liner bore. If liners are forced into position because of dirt or because of interference from dislocated packing rings, they will be out-of-round and cause piston failure.

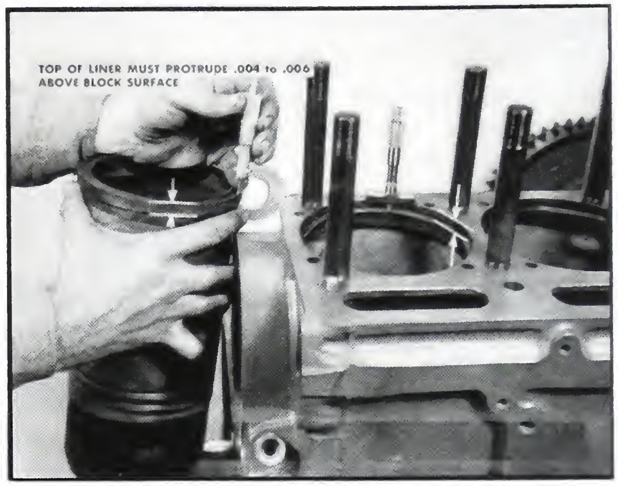


Fig. 2-42. Liner flange extends above block

4. A .010 feeler gauge must pass all the way around the lower part of the liner in the crankcase. If liner is closer than .010 at any point, it must be removed and clearance obtained by grinding the block at the point of interference. When this interference is present it will be found at the cast relief for the supercharger.

Asbestos-Type Rear Cover

LOCATE AND DOWEL: 1. When the asbestos-type rear cover is assembled to the cylinder

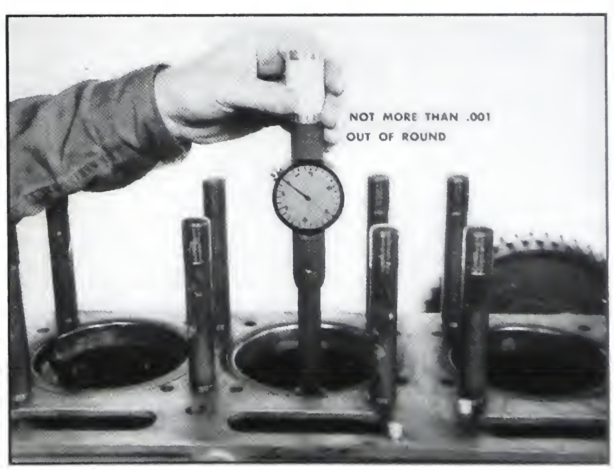


Fig. 2-43. Gauging cylinder liner bore

block, its bore must be in line with the main bearing bore. Use Locating Mandrel, ST-287, to locate and dowel the cover to the block.

2. Assemble the two halves of the cover, with separating gaskets in place, with dowel-fit bolts. Use cap screws to hold the assembly loosely to the cylinder block. Leave asbestos seals out of the cover plate halves.

3. Assemble the No. 6 and No. 7 main bearing caps to the block and tighten main bearing stud nuts.

4. Slide the mandrel through the cover plates and No. 6 and No. 7 main bearing bores. If the rear cover has been previously dowelled, it should fit over the dowels. If not, line up dowel holes in cover and block. Tighten mounting cap screws.

5. Drill and ream two dowel holes in upper plate to smallest permissible size. New blocks have 3/16" dowels, but if redowelled, it will be necessary to increase size by 1/64" over last dowels installed. See Fig. 2-44.

6. Drive in dowels. Remove locating mandrel and rear cover assembly from the block.

7. Complete assembly of rear cover to block as directed on Page 2-31 after laying the crankshaft.

Installing Crankshaft

MAIN BEARINGS AND CRANKSHAFT: 1. All Cummins main bearings are precision-type with shell thickness, bearing material and bear-

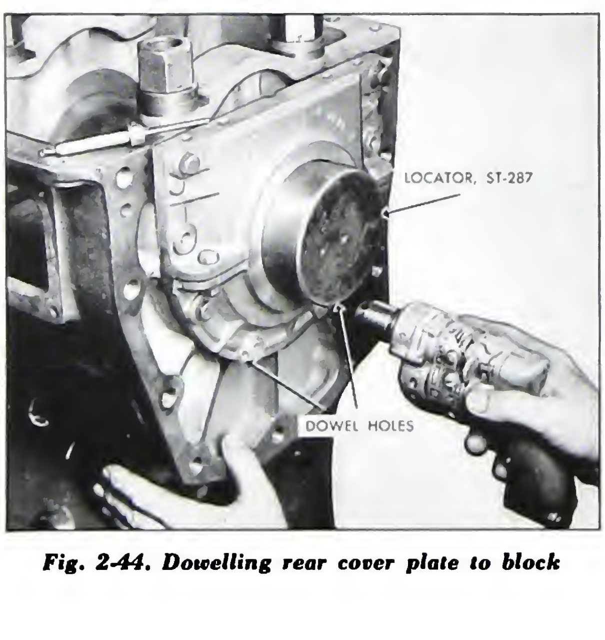


Fig. 2-44. Dowelling rear cover plate to block

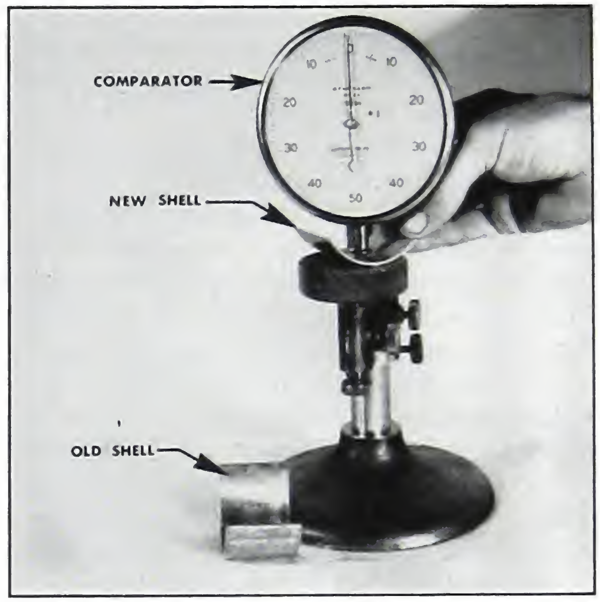


Fig. 2-45. Gauging shell thickness

ing crush accurately calculated and held to close tolerances. Bearing metal may vary from time to time or from one engine model to another as improvements are made by bearing manufacturers or as engine applications differ.

2. When new parts are used the specifications in Table "Bearing Data," Page 2-27, apply to main bearings, connecting rod bearings and thrust half-rings. Main and connecting rod bearings are available in standard .010, .020, .030, and .040 undersizes. Thrust half-rings are available in standard and .010 oversize. When oversize thrust rings are used, they must be in complete pairs.

CAUTION: WHERE OVERSIZE THRUST HALF-RINGS ARE USED ON ONLY ONE SIDE OF THE FLANGE, EXTREME CARE MUST BE USED IN CHECKING CRANKSHAFT POSITION TO MAKE SURE THAT THE CRANK HAS NOT SHIFTED EITHER WAY. SHIFTING MAY CAUSE PISTON BOSSING OR INTERFERENCE BETWEEN CRANK FILLETS AND ENDS OF BEARINGS.

3. Shell thickness must always be measured with ball point micrometers or with a comparator as shown in Fig. 2-45. The difference in shell thickness of a new and an old half will indicate wear of the shell and twice this difference will indicate additional oil clearance caused by bearing wear. Shells should not be re-used if worn more than .002 in thickness or if they are scored or damaged in any other way than by normal wear. Total worn maximum oil clearance must

not vary more than .002 between adjacent main bearings; otherwise, the crankshaft may fail from flexing.

4. The main bearing bore in the block must be 4.749/4.750 after the main bearing stud nuts are tightened to operating tension by the template method as described on Page 2-11.

5. The main bearing journals of a new crankshaft are 4.500/4.499.

6. *Never* use a feeler gauge or lead ribbon to gauge oil clearance. If the dimensions of the main bearing bore, crankshaft journal and shell thickness are within the permissible limits as previously described, the oil clearance will also be within permissible limits as shown in the table. Using a lead ribbon or feeler stock damages the bearing surface of the shell.

7. Turn the block upside down in the engine stand. Make sure that all oil passages in the block and crankshaft are open and clean. Use a clean rag to wipe the main bearing bores and main bearing shells.

Bottom Oiling: The following instructions apply to all engines with lubricating oil introduced through drilled main bearing studs and main bearing caps to bottom halves of main bearings.

1. Lay the upper main bearing shells in the block. Only No. 4 upper main is drilled for lubrication. Bearings No. 1, No. 3 and No. 5 are alike. No. 2, No. 4 and No. 6 are also alike except for the drilled hole in No. 4. No. 7 is the thrust bearing and in this bearing the transverse groove supplies oil to the rear thrust flange.

2. Put main bearing dowel rings on all seven main bearing studs on the exhaust manifold side of the engine. These are the plain, or undrilled studs. Check to see that the milled slots in the main bearing shells match with the dowel rings.

3. Check to see that the drilled oil hole in No. 4 bearing indexes with the drilled hole in the block.

4. Lower half thrust rings must be held by dowels in No. 7 main bearing cap as explained on Page 2-17. Upper thrust rings need not be dowelled to the block. The dowelled lower halves will keep them from turning.

Check clearances between (a) thrust rings and bearings pointed "A" Fig. 2-30, (b) dowel pins and thrust rings point "B" Fig. 2-30 and (c) parting line point "C" Fig. 2-30. Clearance must be as specified in directions accompanying Fig. 2-30, Page 2-17.

5. Lubricate each main bearing with good, clean lubricating oil before attempting to lift the crankshaft into place. For lifting the crankshaft, use two hooks protected with rubber hose or copper tubing or a rope sling at two crank throws. It is very important that the crankshaft be lowered squarely into place.

All four thrust half-rings for No. 7 main bearing are identical. Turn the upper thrust half-rings into place on each side of the upper main

TABLE—BEARING DATA

PART OR LOCATION	NEW DIMENSIONS Minimum	NEW DIMENSIONS Maximum	WORN REPLACEMENT Limit
Main Bearings—Copper Lead			
Shell Thickness	.1230	.12375	.1215
Journal Clearance	.0015	.005	.0075
.010, .020, .030 and .040 undersize main bearing shells are available.			
Thrust Half-Ring Thickness	.246	.247	.243
End Clearance	.007	.013	.022
Thrust Half-Rings are also available in .010 thicker than standard for ground flange.			
Connecting Rod Bearings—Copper Lead			
Shell Thickness	.07225	.073	.070
Journal Clearance	.0015	.0045	.007
.010, .020, .030 and .040 undersize connecting rod shells are available.			

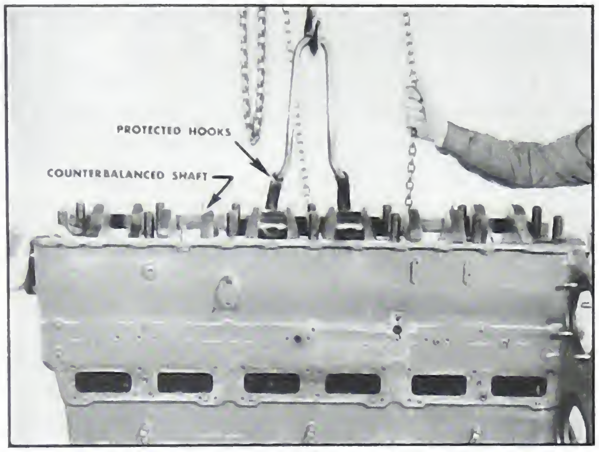


Fig. 2-46. Laying the crankshaft

bearing shell with the babbitt-grooved side next to the crankshaft flange thrust face.

All journals on the crankshaft are drilled for lubrication except the center main bearing.

6. Numbers 1, 3 and 5 lower main bearings are alike, and numbers 2, 4 and 6 are alike. Oil holes and grooves are provided in all lower main bearings.

On four-cylinder engines bearing numbers 1 and 3 are alike. Numbers 2 and 4 are alike. Number 5 is the thrust bearing.

7. Before assembling the lower main bearings to the crankshaft, make sure each shell is thoroughly lubricated with clean oil and all burrs removed. The back of the bearing shell and the bearing seat must be carefully cleaned of even the small particles of dirt or metal. Be sure that the small dowel ring groove, on one side of the bearings, is placed opposite the camshaft side of

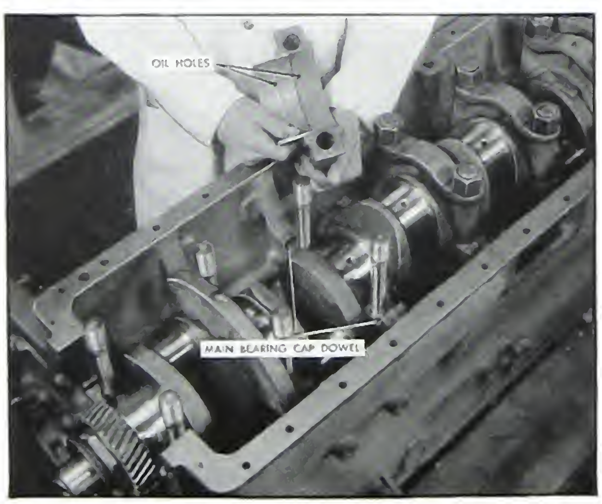


Fig. 2-47. Lower main bearings

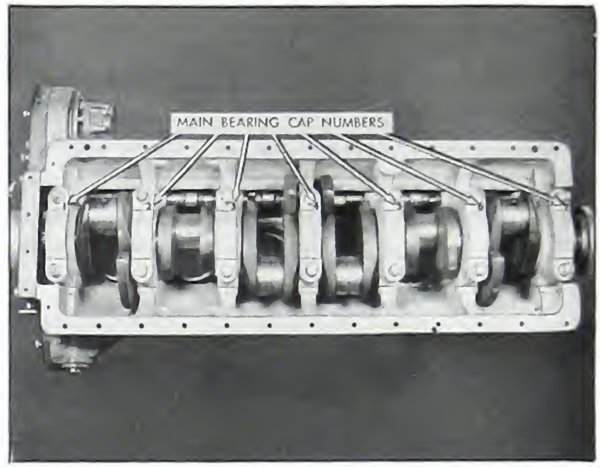


Fig. 2-48. Main bearing caps

the engine.

8. Snap the lower main bearing shells into place over the crankshaft in the block.

The block is milled so that 1/16″ more than half the main bearing bore is in the block. This permits the shell to be snapped into place and held while working under an installed engine.

9. Each main bearing cap is numbered to correspond with an upper main bearing. Place each cap over the stud with the number to the camshaft side of the engine. Main bearing caps *are not interchangeable.*

The cylinder block is precision machined for the cap to fit into its correct position. After each main bearing shell has been put in position by hand, use a soft hammer to tap the caps down securely into place. Never file the caps to reduce the clearance.

10. Lubricate the threads on each main bearing stud. Place new lock plates in position before installing the stud nuts.

11. Tighten the main bearing stud nuts alternately, a little at a time, to 320 foot-pounds.

12. Loosen and retighten the stud nuts by the template method as instructed on Pages 2-11 to 2-13.

13. Crankshaft end clearance must be not less than .007 nor more than .013 before allowing for permissible wear of the crankshaft flange. Alternately bumping one end, then the other, of the crankshaft with a block of wood will generally bring the end clearance to a minimum of at least .007. This method is to be preferred to filing off bearing metal from the thrust rings.

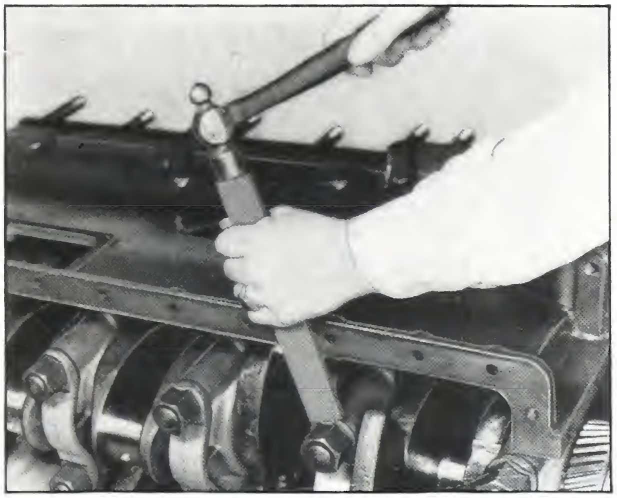


Fig. 2-49. Lock plates and stud nuts

True crankshaft end clearance must be determined with a dial indicator gauge. Check it as instructed on Page 2-13 and as illustrated in Fig. 2-20.

14. Test the crankshaft for free turning by hand. It should be free enough so that it can be hand cranked readily after being started by using one of the crankshaft flange dowels as the crank.

15. Bend each of the lockplates up against two flat sides of its main bearing stud nut. Fig. 2-49.

Top Oiling Main Bearings: All current production H and NH engines are supplied with grooved upper and solid lower main bearing shells. Lubricating oil is forced into the grooves through holes in the top bearing shells which index with holes in the block. The following instructions apply to installation of these bearings:

1. All main bearing studs are solid with no drilled holes or milled slots to transfer lubricating oil.

2. Upper bearing halves of Nos. 1, 3, 5 are alike. Likewise, the solid lower halves are alike.

3. Upper bearing halves of Nos. 2, 4, 6 are alike. Likewise, the solid lower halves are alike.

4. Upper and lower halves of No. 7 main bearing are different and *must not be interchanged.*

CAUTION: SOLID LOWER SHELLS SHOULD NOT BE USED WHERE CONTINUOUS-GROOVED BEARINGS HAVE BEEN USED AND CRANKSHAFT HAS NOT BEEN REGROUND.

Upper No. 7 shells have the oil groove off-center. The wide portion of the shell goes toward the flywheel end.

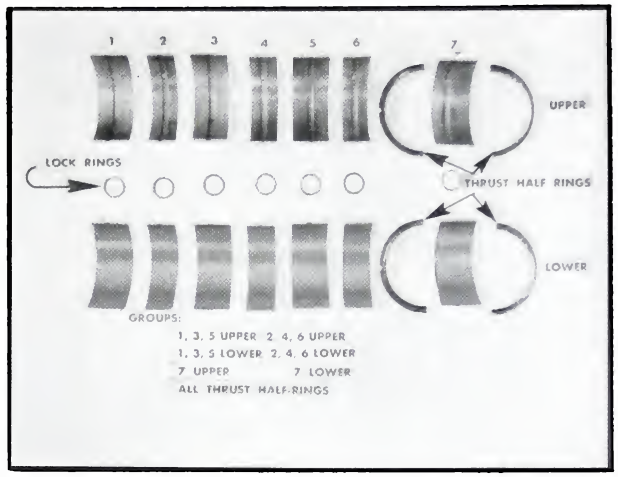


Fig. 2-50. Main bearing shells

5. The above bearing shells can be used in all H and NH engines. *Old-style continuous groove upper and lower shells must be used only where engines have the 7/8" hose-type oil lines.*

6. With the exceptions noted in the five preceding steps, all other instructions given under "Installing Crankshaft" apply to installation of continuous-groove upper bearings.

Connecting Rods And Pistons

INSTALL PISTON RINGS: 1. Push each of the piston rings down in the cylinder liner, in which it will work, with the head of a bare piston and check piston ring gap as shown in Fig. 2-51.

2. File ends of the piston rings if necessary to obtain the minimum ring gap clearances as shown in the table "Piston Ring Data".

3. Be sure to use the type ring specified for the piston. Consult latest parts lists.

4. Assemble the rings to the pistons with the word "TOP" to the top.

ASSEMBLY: 1. Piston-to-liner clearance is determined by inspection of piston skirt diameter (Table—Piston Dimensions, Page 2-22) and inside diameter of cylinder liner. New clearances vary from .004/.006 with H cast-iron pistons to .0095/.0115 with NHRS aluminum pistons.

2. Clearance of piston pins in new cast-iron pistons is .0004/.0008. Aluminum pistons should be heated in boiling water before installing the pins because the fit is .0001 clearance to .0003 interference at 70° F. Always lock the pin in

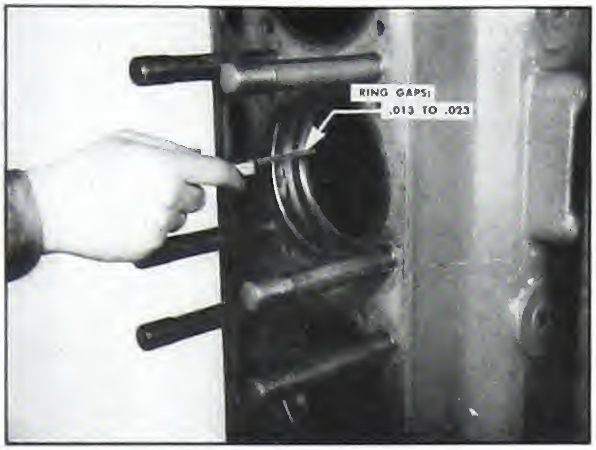


Fig. 2-51. Measuring ring gap

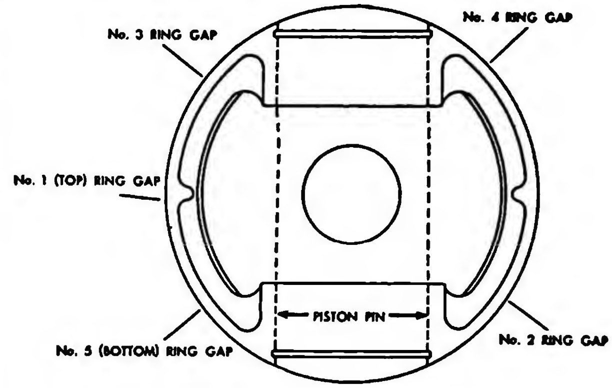


Fig. 2-52. Placing piston ring gaps

position with snap rings.

3. To assure better performance from the piston rings, stagger the ring gaps so they are not in line with each other or with the piston pin.

4. Oil pistons, rings and cylinder liners with clean lubricating oil.

5. Use a standard ring compressor to compress rings and insert piston and rod assemblies in the liners with the numbered side of the rod to the camshaft side of the engine. Connecting rods and caps are numbered to correspond with their respective cylinders and the numbers of rod and cap must match as shown in Fig. 2-39.

6. Slide upper rod shells in position between crank journals and rod bores. Place lower shells in caps. Locking tangs of shells must fit in milled recesses of rod and cap on camshaft side of engine.

7. Tighten connecting rod bolt nuts to 140 foot pounds with a torque wrench.

8. Loosen the nuts and redraw with a torque wrench to 50/55 foot pounds. Advance each of the nuts another 60° (one "hex" of the nut) to correspond with the template method of tightening as instructed on Pages 2-11 to 2-12.

9. Tap the connecting rod cap with a soft hammer to be sure that there is side clearance. This clearance as gauged with feelers should be .006/.011.

10. Check the clearance between the milled faces of the rod and piston bosses. There must be at least .020 clearance on the close side of the rod in addition to the crankshaft end clearance.

TABLE—PISTON RING DATA

Piston Ring	Used On	Type	Ring Width	Ring Gap
65354	H	Compression	.119/.1195	.010/.020
65327	H	Compression	.1235/.1240	.010/.025
65326	H	Oil	.1860/.1865	.010/.018
65325	H	Oil	.2485/.2490	.010/.018
43421	HS	Compression—Chrome Plated	.148/.149	.013/.023
42330	HS	Compression	.150/.1505	.013/.023
42331	HS	Oil	.244/.2445	.010/.018
41878	HR, NH, NHS, NHRS	Compression	.150/.1505	.013/.023
42035	HR, NH, NHS, NHRS	Oil	.244/.2445	.013/.023
42360	HR, NH, NHS, NHRS	Compression—Chrome Plated	.148/.149	.015/.025
43905-1	HR, NH, NHS, NHRS	Compression—Top Over Width	.1795/.1805	.015/.025
43906-1	H	Compression—Top Over Width	.1815/.182	.013/.023
69602-1	H	Compression—Top Over Width	.1815/.182	.010/.025
43914-1	HS	Compression—Top Over Width	.1795/.1805	.013/.023
44431-1	HR, NH, NHS, NHRS	Compression—Top Over Width	.1815/.182	.013/.023

This is extremely important because if the rod should boss it will cause scoring or seizure of piston and liner.

11. Turn the crankshaft as each piston and rod assembly is added to gauge additional drag. This will be perceptible but must not be excessive for any one rod assembly. After all rods and pistons are assembled, the engine must be free enough to crank easily with a hand crank.

Rear Covers

Two types of rear covers are provided for H and NH engines. The most commonly used type employs an asbestos oil seal around the crankshaft. The second type is referred to as the labyrinth-type.

ASBESTOS-SEAL-TYPE REAR COVER: 1. Dowels in cylinder block and dowel holes in cover plates must be located as previously directed on Page 2-25 before permanent assembly of rear cover to cylinder block.

2. Shellac a new gasket over the dowel pins on the rear of the cylinder block. Assemble the upper cover plate over the dowel pins and tighten down the four cap screws and lock washers. With the crankshaft pried toward the cover plate, check the clearance between the crankshaft flange and the opposing face of the cover plate. Clearance should be .004 to .008. See Fig. 2-54.

3. The .004 to .008 clearance between the crankshaft flange and the opposing face of the cover plate can be obtained by use of .005 and

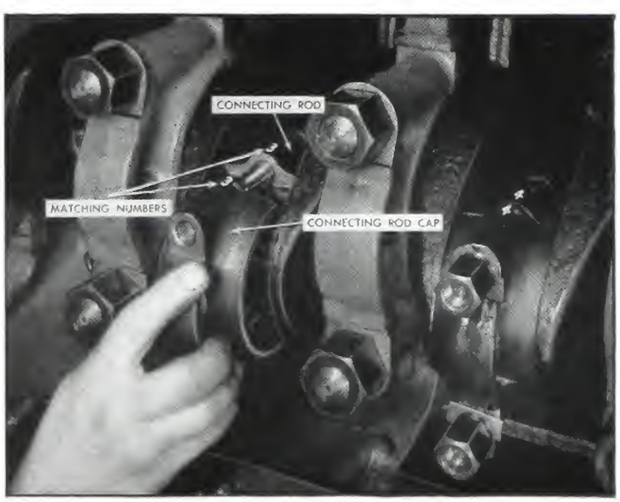


Fig. 2-53. Matched numbers on rod and cap

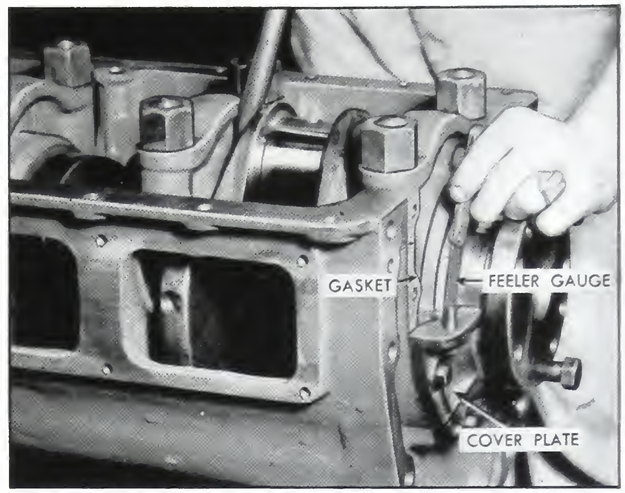


Fig. 2-54. Checking clearance on cover plate "1"

.010 gaskets to move the cover plates to or from the cylinder block. See Fig. 2-54 and Fig. 2-55.

4. The clearance between the crankshaft and the bore of the cover plate should be .006. This must be obtained by use of locating mandrel, ST-287, as directed on Page 2-25. When installing new cover plates, this clearance must be correct before the dowel pin holes are reamed to oversize.

5. Remove the cover plate and install new asbestos seals into the recess of both upper and lower cover plates. New asbestos seals must be beveled on three sides of each end, 1/32" by 45°, leaving the inside edge square. The ends of the seal should extend 1/32" above joining surfaces of cover plates. The seals must be thoroughly oiled, as an oil leak will develop if dry seals are

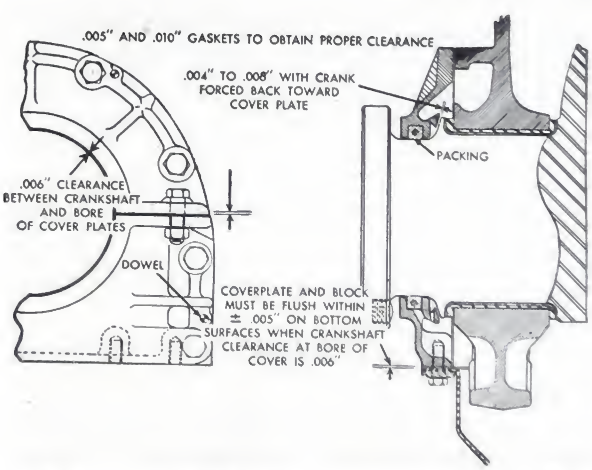


Fig. 2-55. Checking clearance on cover plate "2"

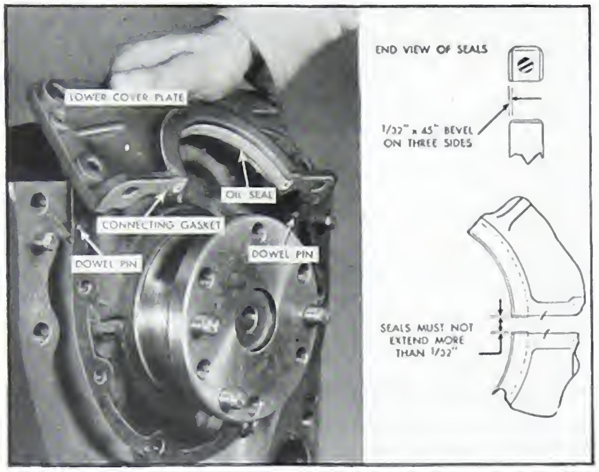


Fig. 2-56. Oil seals in the cover plate

run on a dry shaft. Make sure that asbestos seals are well seated in grooves. See Fig. 2-56.

6. Shellac new connecting gaskets to the lower cover plate. Assemble the lower plate to upper plate and bolt together tightly with dowel fit bolts, lock washers and nuts. Install cap screws and lock washers to the cover plates and pull up evenly to the cylinder block over the dowel pins.

LABYRINTH-TYPE REAR COVER: 1. Locator, ST-162, should be used over the crankshaft end flange to locate the cover plate to the cylinder block. If the dowel holes are not in proper alignment they must be reamed to oversize and oversize dowels be installed. See Fig. 2-57.

2. Tighten cover plate in place to the block.

3. The oil slinger of the labyrinth-type seal is to be attached loosely to the flywheel and tightened after the flywheel and the slinger are assembled over the crankshaft end flange. As will be seen from the cross section, Fig. 2-58, the cap screws used to mount the slinger to the flywheel must not be too long. Cap screws that are too long will rub against the cover plate and damage it.

CAMSHAFT: 1. The camshaft part number is stamped on the rear end of the camshaft. Make sure that the proper camshaft has been supplied for the engine model as listed in current parts book.

2. Assemble the camshaft thrust washer with the grooved face next to the camshaft gear.

3. Before installing the camshaft, see that all cam bushings are properly lubricated. Rotate the camshaft while installing it in the block. This

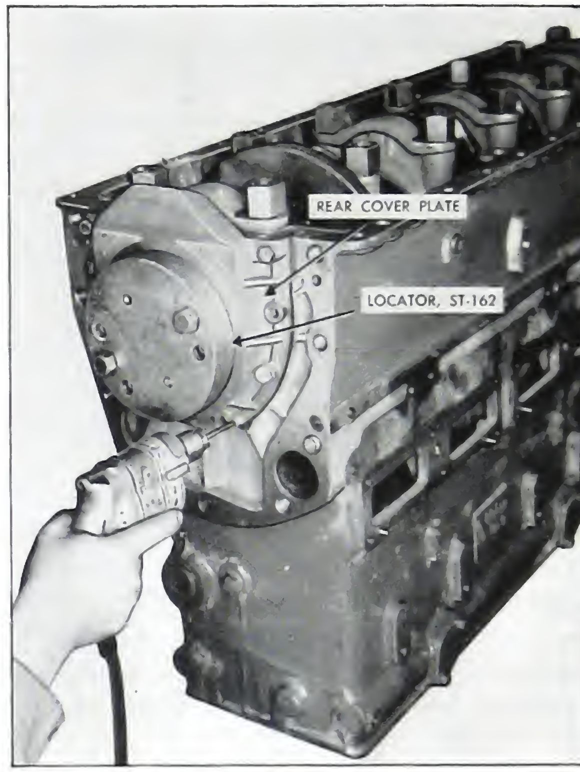


Fig. 2-57. Locating new cover plate to block

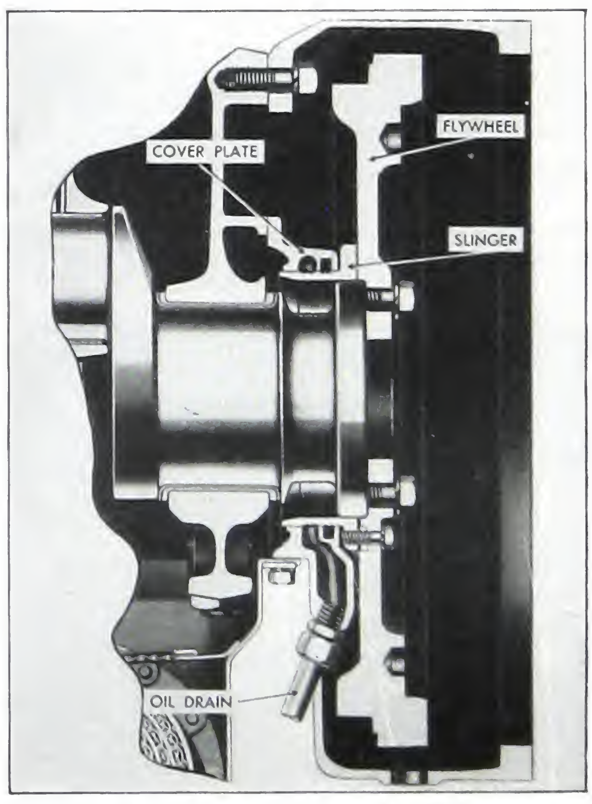


Fig. 2-58. Labyrinth type oil seal

permits the lobes of the cam to pass through the camshaft bearings and allows the camshaft to enter freely.

4. Index the "0" on the camshaft gear with the "0" of the crankshaft gear. Timing will be correct if the number on the camshaft gear is indexed with the number on the camshaft, and if the "0's" on the crankshaft gear and camshaft gear are indexed.

5. On drilled camshafts, make sure that the pipe plug is installed and tightened in the end of the camshaft to provide a seal for the lubricating oil.

6. Camshafts currently used in engines with top oiling are undrilled.

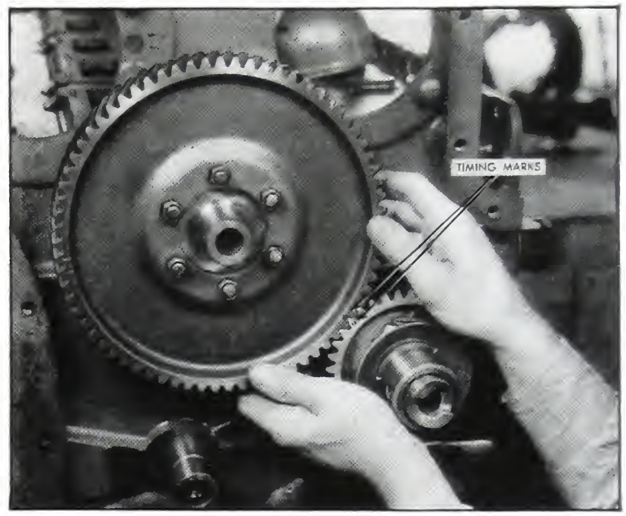


Fig. 2-59. Timing the camshaft

GEAR DATA: 1. Two types of gears are used in the gear trains of the above mentioned engines. Gears used in H and HS series belt driven engines differ in helix angle, lead, pitch, depth of teeth and dedendum for those used on HS (gear driven) and NHS series engines.

2. Because of the difference in the gear teeth form, it is not possible to interchange gears of one type with those of the other. Thus, if a lubricating oil pump, crankshaft, fuel pump, camshaft or idler gear is being replaced, care must always be exercised to determine that the proper gear is used to match with the train in which it is being fitted.

3. Our parts books specify the proper gears to be used with each type engine. To make this information more readily available to you, we are including the following table.

GEAR BACKLASH: Under normal conditions, gears in the gear train will last through several engine overhauls; however, they should be checked for visible wear and gear backlash should be measured at each overhaul.

Minimum Gear Backlash: 1. Use a dial indicator gauge or a narrow feeler gauge blade to check backlash of all gears in the train at each quadrant as each gear is rotated. Minimum backlash must be at least .002. Normal backlash for new gears in the gear train is .005 to .006.

2. If gears have insufficient backlash they will whine when the engine is started and fail very quickly. Whining is always an indication of in-

TABLE—GEAR DATA

ENGINE MODEL SERIES Name	H *NH Part No.	HS (Belt Driven) Part No.	HS (Gear Driven) Part No.	**NH Part No.	NHS, NHRS Part No.
Crankshaft gear	9168–2	9168–2	65261	9168–2	65261
Lubricating oil pump drive gear	9169–2	9169–2	65263	9169–2	65263
Fuel pump drive gear	9177–2	9177–2	65262		
Idler gear	4772–1, ***41894	None	40715	41894	41767
Supercharger drive gear	None	None	65252		65252
Camshaft gear (Right Hand)	4765–2	4765–2	40716–1	4765–2	40716–1
Camshaft gear (Left Hand)	42772	42772	42773	42772	42773
Generator drive gear	9171–1, ***67085	None	None	67085	None
Compressor drive gear	9170–2	9170–2	66363	9170–2	66363

*Used on NH Engines, Serial Nos. 43576 through 43655.

**Used on NH Engines, after Serial No. 43655.

***Used on H and HR Engines after Serial No. 117472.

sufficient gear lash or improperly mated gears.

Maximum Gear Backlash: 1. Worn gears will have more backlash, and if it exceeds .010 or .012 the gears will rattle. In bus or similar applications where noise is objectionable it may be advisable to install new gears at this point.

2. If noise is not an objectionable factor gears probably will not need to be replaced unless backlash exceeds .020 or unless they are visibly worn or damaged.

3. Generator drive and lube pump drive gears can be used with more backlash than pinion or other gears pulling heavy or uneven loads.

Worn and New Gears: A new gear should not be mated or run with a badly worn gear.

Idler Gear

1. From the gear data provided, select the proper type idler gear and install it over the idler gear pin. The gear teeth of the idler gear should be flush with the camshaft gear teeth.

2. The idler gear does not need to be timed with the camshaft gear. It engages the generator drive gear, or supercharger drive gear.

Gear Case Cover

H, HR AND NH ENGINES: 1. Shellac a new gasket to the gear cover and assemble the cover to the cylinder block over the dowel pins.

2. Assemble the oil pressure regulator in the end of the camshaft. Two lock washers and cap screws hold the oil pressure regulator thrust plate, when used, to the gear case cover.

3. Use ST-251 for H and HR engines and ST-461 for NH engines to fit over the fuel pump and compressor drive shaft to locate new gear case covers to the block for dowelling. See Fig. 2-60.

NHS, NHRS AND GEAR DRIVEN HS ENGINES: 1. If it is necessary to install a new gear case cover on any of these engines the new cover must be properly located and dowelled as described below:

2. Shellac a new gasket to the gear case cover.

3. Test the fit of the idler gear pin support and the camshaft end bearing support in the gear case cover. Remove any dirt or burrs.

4. Lubricate the exposed part of the oil pan gasket to prevent its being damaged when the cover is pulled up to the block.

5. Secure the cover to the block with lock washers and cap screws. Avoid damaging the oil pan gasket.

6. Install the idler gear pin support to the gear case cover. Loosen the cap screws enough to allow the cover to be shifted, if necessary, during this and the next operation.

7. Assemble the camshaft end bearing support to the gear case cover, while shifting the cover as needed, to obtain proper alignment.

8. Tighten all mounting cap screws.

9. Drill and ream the dowel holes to 9/16". Install new 9/16" inside threaded dowels to the gear case cover and cylinder block.

10. Assemble the cover and gasket to the idler gear pin support and draw up with lock washers and cap screws. Measure the clearance between the support and gear case cover with a feeler gauge. Pull the support from the gear case cover and use enough shims (65259) to obtain .010 to .012 clearance between the idler gear and support when reinstalled. Assemble the shims, packing,

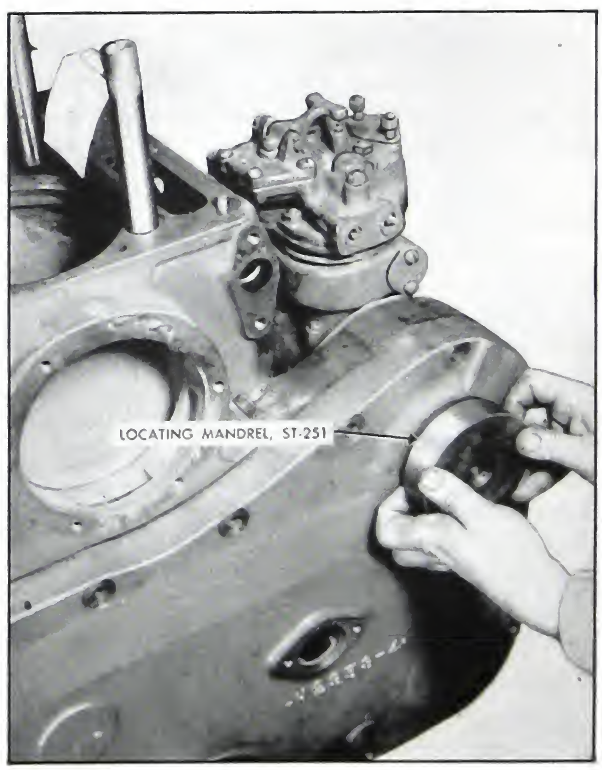


Fig. 2-60. Locating gear cover with ST-251

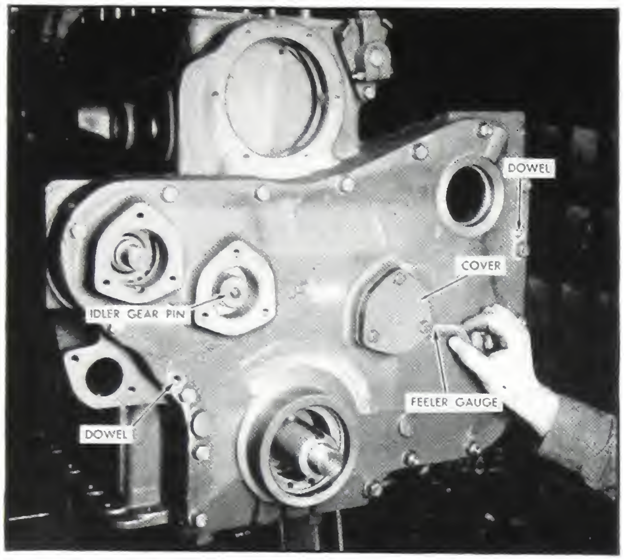


Fig. 2-61. Clearance between bearing support and gear case cover

support, gasket and cover to the gear case cover with lock washers and cap screws. Allowance of approximately .004 must be made for compression of shims.

NOTE: NHS and NHRS engines use idler gear ball bearing. Step 10 does not apply to this model engine.

11. Check the end play between the camshaft end bearing support and cover in the same manner as for the idler gear pin support. Use the same method and as many shims (65259) as required to obtain the end clearance of .008 to .010 after installation. After assembly, use an indicator gauge at the rear of the camshaft to check camshaft end clearance.

NOTE: A regulating plunger must be installed in drilled camshafts to regulate lubricating oil pressure. This is used only with bottom-oiling of main bearings. When undrilled camshaft is used the lubricating oil pump must have a pressure relief valve.

Compression Release

1. With new gaskets, assemble the compression release shaft bearings, when used, to the side of the block and secure with lock washers and cap screws. Late style engines have the block bored for the compression release shaft and do not use the bearings.

2. The compression release shaft runs the full length of the block on the camshaft side. It contains a lifting notch for each intake valve push rod. Insert the shaft in the cylinder block and install the packing and packing glands.

3. Tighten in place with lock washers and cap screws.

4. Lock the compression release shaft in place with the small lock screw in the flywheel end of the cylinder block. Replace expansion plug at the rear of the compression release shaft, if removed.

Lubricating Oil Pipe

1. The lubricating oil pipe carries oil from the camshaft to the upper rocker housing. There is one oil pipe for each pair of cylinders.

2. With the small hole drilled through the pipe at the top, install the pipe between each pair of cylinders. Tighten the pipe by inserting a small pin punch through this hole.

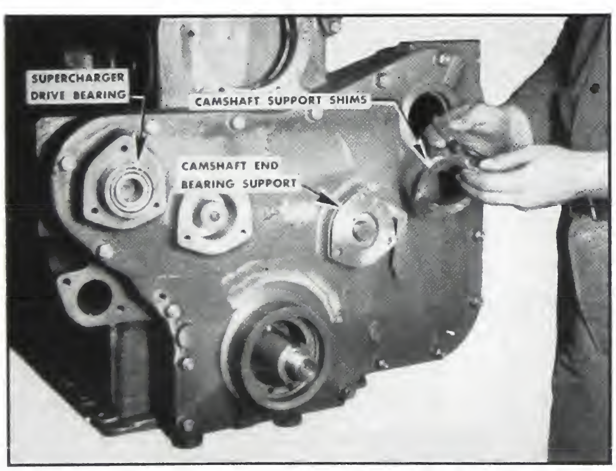


Fig. 2-62. Measuring shims to obtain end clearance

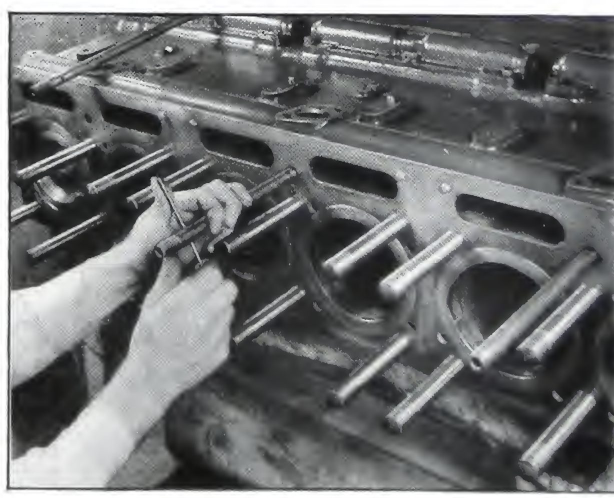


Fig. 2-63. Lubricating oil pipe

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SECTION III

UNIT NO. 2

Cylinder Heads

CLEANING, DISASSEMBLY AND INSPECTION

STEAM CLEANING: Steam clean the cylinder heads to remove all dirt and oil accumulations.

VALVES AND SPRINGS: 1. Use a valve spring compressor to compress the valve springs and remove the half collets. Remove the valves and springs from the cylinder head.

2. ST-373 is a simple valve spring compressor designed to be used on the cylinder head studs to compress one valve spring at a time. It can be used either at the bench or on an installed engine. Fig. 3-1.

WATER TEST: 1. Install an old scrap injector or ST-384 injector sleeve holding tool in each injector sleeve and pull down to 8-10 foot-pounds. This is necessary to seal the lower end of the non-flared injector sleeve.

2. Place the cylinder head in a water test fixture and test for leaks at 35 to 85 pounds pressure. Check particularly around the valve seats and the injector sleeve seats for any cracks, even though such cracks might not show water leakage. This type of crack is caused by tightening down injectors in excess of factory recommendations. See Fig. 3-2.

3. Open the water outlet valve of the test fixture and check for free water circulation through the cylinder head. If the water passages show any restriction it will be necessary to remove all plugs and injector sleeves to clean the water jacket of the accumulation of salt, lime or sludge.

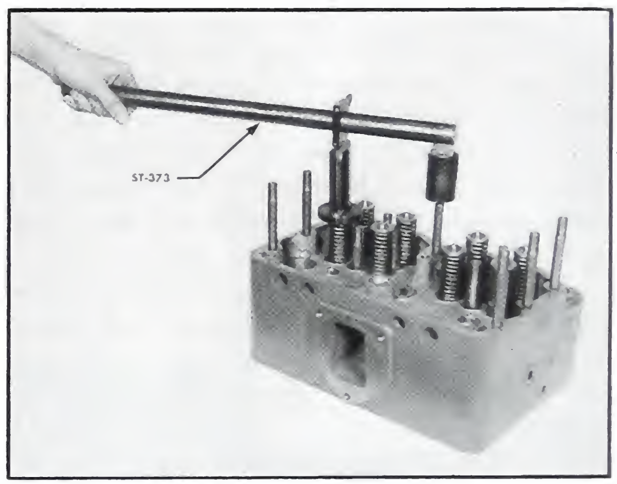

Fig. 3-1. Valve spring compressor

VALVE SEATS: 1. Inspect the valve seats. Valve seat inserts must be marked for replacement if they are loose enough to bounce when tapped lightly. Slight looseness that can be found only by tapping with oil on a cold head is not objectionable.

2. If the seat width exceeds .125 when reground it should be narrowed by grinding with a 60° angle stone or new inserts should be installed. See Fig. 3-17.

INJECTOR SLEEVES: 1. Check the injector seat in the injector sleeve. If the seat is scratched or distorted, or if the sleeve is not perfectly sealed, it should be marked for replacement. Injector

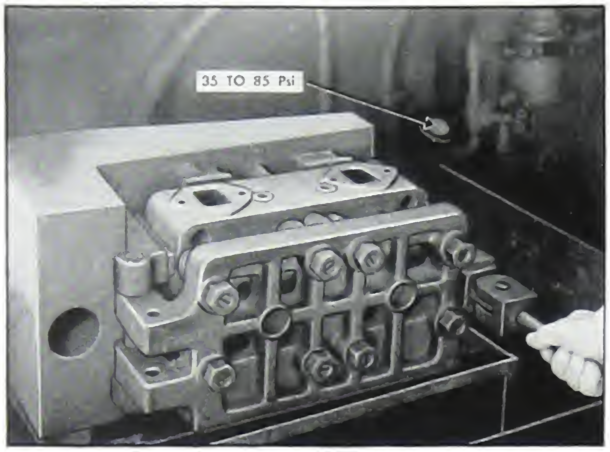

Fig. 3-2. Water testing cylinder head

seats can be checked with Prussian Blue and a new injector cup on an injector body.

2. If the bore for the injector sleeve in the cylinder head is flared at the milled face of the head, it is not advisable to attempt to reseal the lower part of the injector sleeve in the cylinder head. If a sleeve has been sealed once at this point, and used for some time, the copper becomes hard and additional swaging generally causes cracks. Such cracks might not show on a water test but would lead to an early failure.

3. On latest cylinder heads, the injector sleeve seals in the bore taper, and the sleeve is no longer flared at the bottom. Non-flared sleeves will need replacing only when seats are scratched or cut too deep.

4. Injector sleeves that have passed all the tests above should be further checked for seat depth. To do this, fasten an injector in place and gauge the injector tip protrusion. This can be done with Starrett 196-A indicator set or with a special slotted gauge. Injector cup tips should protrude .040 to .055 beyond the cylinder head as shown in Fig. 3-3. Reseated injector sleeves can be used until injector tip protrusion is as much as .065.

5. To remove worn out sleeves, cut them from the cylinder head with a 3/8" gouge chisel at the points of sealing and drive out from the lower end. (Fig. 3-4).

CLEANING: 1. Clean the cylinder head thoroughly inside and outside. After steam cleaning and disassembly, submerge it in a tank of cleaning solution heated to near boiling temperature.

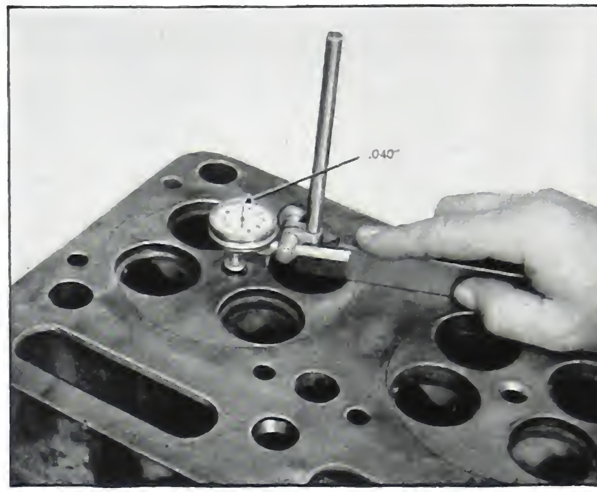

Fig. 3-3. Injector tip protrusion

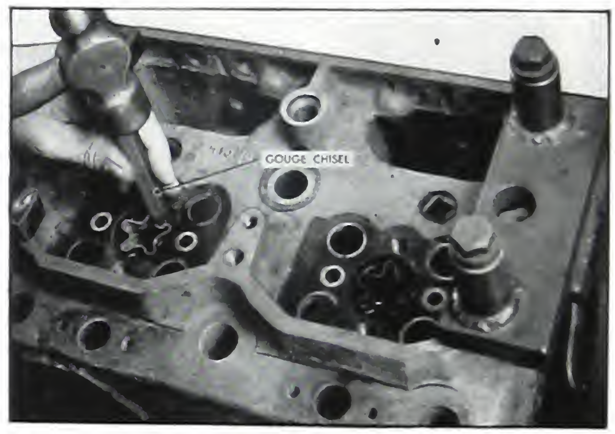

Fig. 3-4. Removing injector sleeve

Turko or Wyandotte "G" metal cleaner are satisfactory cleaners. Other good solvent cleaners are available. Follow manufacturer's recommendations as to use.

2. Salt or lime deposits, grease, etc., inside the water jacket of the cylinder head can be more easily removed if the solvent is circulated. To remove heavy deposits of lime, it probably will be necessary to use an acid-type cleaner. To realize full value from the acid, some means will have to be provided to insure circulation.

CAUTION: THE USE OF ACID IS EXTREMELY DANGEROUS TO WORKMEN AND INJURIOUS TO MACHINERY. ACID SHOULD NEVER BE USED IN THE MACHINE SHOP OR NEAR ANY MACHINERY SUBJECT TO RUSTING. ALWAYS PROVIDE A TANK OF STRONG SODA WATER AS A NEUTRALIZING AGENT, IF ACID IS TO BE USED.

3. Clean the valves and valve springs and collets by submerging in the solvent in a wire basket.

INSPECT VALVES AND GUIDES: 1. Inspection is necessary to avoid wasting good parts and to prevent possible failures. Careful inspection and checking is necessary before and after reworking.

2. Inspection of valves should start with a good cleaning. Clean with a buffer and polish with crocus cloth.

3. Discard valves if:

a. Heads are cupped, cracked, pitted or worn too thin to regrind within limits.

b. Stems are scored or worn below replacement limits.

c. Collet recesses are worn so new collets will not fit securely in recesses.

4. If the old valve guides are worn beyond the worn replacement limits shown in the Table, "Valve Guide Data," press them out and press in new guides.

5. A plug gauge is *not* satisfactory to gauge worn holes. It will not detect an out-of-round hole. Instead, use a small bore gauge—Starrett No. 829-D, or similar. (Fig. 3-5).

6. To use a small bore gauge, set it (with accurate micrometers) at .0002 inch above the worn replacement limit, as shown in the Table, "Valve and Guide Data," and use as a "No-Go" gauge. Gauge the hole at several points cross-wise and end-wise of head.

VALVE SPRINGS: 1. Valve springs should be tested on a valve spring scale that is capable of very accurate measurements of spring lengths by means of standards and a dial indicator gauge. See Fig. 3-6.

Some of the popular spring testers do not have accurate means of checking length. The indicator gauge and standards can be adapted to most of these testers.

2. Weak valve springs may cause valve flutter which will cause excessive wear on both the valve and seat. Valve flutter interferes with the valve timing and may cause the valve to strike the piston head. Warping, cracking and breaking are natural results of weak valve springs.

3. Old valve springs can be used with washers or spacers up to 1/16 inch maximum thickness

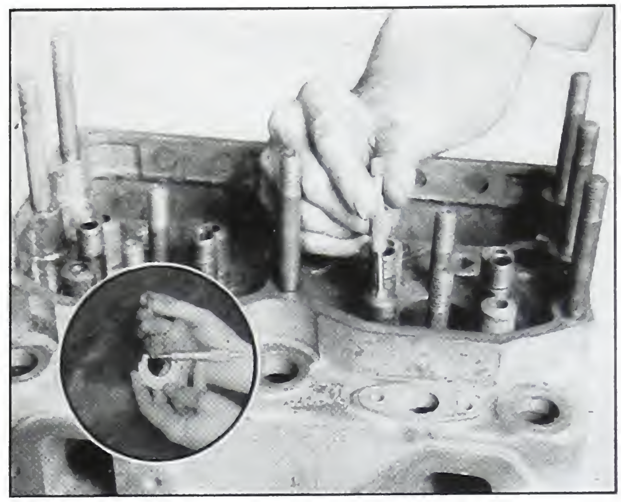

Fig. 3-5. Checking valve guides

to make them check within the load limits shown in the Table, "Valve Spring Data".

TABLE: VALVE SPRING DATA

Valve Spring Part No.	Free Length	Load Limits	Length
66870	3 5/16	74 to 82 lbs. @	2 1/4 in.
		104 to 114 lbs @	1 27/32 in.
68997	3 31/64	110 to 122 lbs. @	2 11/16 in.
		179 to 198 lbs. @	2 3/16 in.

Fig. 3-6. Testing valve spring

TABLE—VALVE AND GUIDE DATA

PART NO. AND NAME	Diameter New	Worn Limit Diameter	Minimum Head Thickness at Edge
9167–Y Exhaust Valve	(Stem) .496/.497	.495	1/16
69032 Intake Valve	(Stem) .496/.497	.495	1/16
9210–1 Valve Guide	(I.D.) .4995/.5005	.5015	
68276 Intake Valve	(Stem) .402/.403	.401	1/16
70130 Exhaust Valve	(Stem) .402/.403	.401	1/16
66890 Valve Guide	(I.D.) .4045/.4052	.406	
42184–1 Crosshead	(Stem) .3713/.3708	.370	
66889–1 Crosshead Guide	(I.D.) .3755/.3760	.378	
ST-284 Valve Guide Reamer			
Pilot End Diameter	.497		
Cutting Flutes Diameter	.5002/.5004		
ST-285 Valve Guide Reamer			
Pilot End Diameter	.4023		
Cutting Flutes Diameter	.4049/.4051		

4. After valves and valve seats are reground, the valve heads seat deeper in the cylinder head, and more valve stem protrudes above the guide. This allows valve springs to extend beyond the length limits shown in Table, "Valve Spring Data," and causes weak spring action. Use spacers to compensate for the regrinding but do not reduce spring length, as shown in the Table by more than 1/16 inch. Using too many spacers will cause the compressed spring to become a solid sleeve.

5. Check the overall height of the cylinder head. New cylinder heads are 5½" in height. (Fig. 3-7). If this dimension is less than 5½" it indicates that the cylinder head has been welded and remilled (or at least remilled) on the face. Welded and remilled cylinder heads must be very carefully checked to determine that the new injector sleeves can be installed and seated to provide proper injector cup tip protrusion of .040 to .055. Many welded cylinder heads are not suitable for rebuilding.

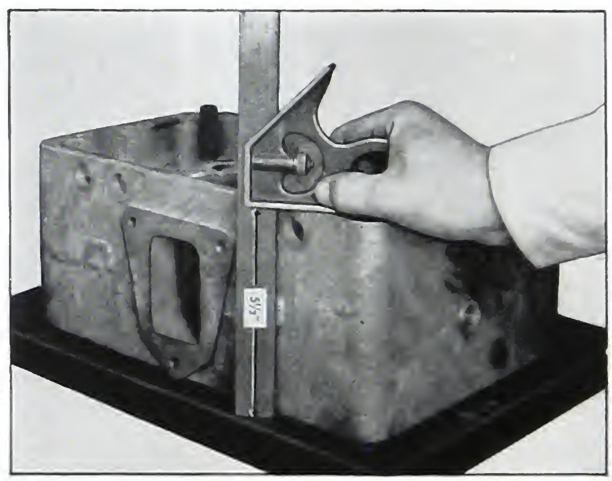

Fig. 3-7. Checking height of cylinder head

INSPECTION DURING REBUILDING: During or after rebuilding, perform the remaining inspection checks as indicated under the rebuild heading.

REBUILDING

HOLDING FIXTURE: A cylinder head holding fixture, ST-213, will save a great deal of time and effort during the following operations. All H and NH cylinder heads can be used in this fixture and revolved through 360° to make them readily accessible for rebuilding operations. See Fig. 3-8.

VALVE GUIDES: 1. Remove the old valve guides marked for replacement. They can be driven out with a simple mandrel from the under side of the cylinder head. Use a hardwood block or properly fashioned mandrel to drive or press in new valve guides.

2. Use special carboloy inserted piloted reamer, ST-284, to ream Model H valve guides, or ST-285 for Model NH guides in a drill press and preferably with a floating tool holder. Always ream from the milled, or bottom, side of the cylinder head. The top of the head must be supported on parallels instead of the studs. Reaming from the bottom of the head provides for more clearance at the part of the valve stem that gets hottest. (Fig. 3-9).

3. Use lubricating oil or soluble oil and water solution for a good finish inside the guide. Reamers must be protected in handling to avoid breaking carboloy tipped flutes.

CAUTION: SPECIAL CARE MUST BE USED WITH THIS AND ALL OTHER CARBOLOY TIPPED TOOLS TO AVOID BREAKING INSERTS BY CARELESS HANDLING. CARBOLOY TIPPED TOOLS MUST BE SHARPENED ON A DIAMOND IMPREGNATED WHEEL.

4. New H valve guides must be reamed to .4995/.5005; NH to .4045/.4052.

VALVE CROSSHEAD GUIDES: 1. Beginning with engine Serial No. 87738 all NH engines have No. 66889-1 grooved crosshead guides to provide an oil relief between the guide and the crosshead stem. Older engines have an oil relief in the crosshead stem either by a drilled hole or by a groove on either side of the stem.

2. If no oil relief is present, or if the guides are worn beyond the limits as shown in the Table, "Valve and Guide Data," remove the old crosshead guides and press in the new grooved guides.

3. New crosshead guides are made to size and it is not often necessary to remove any material.

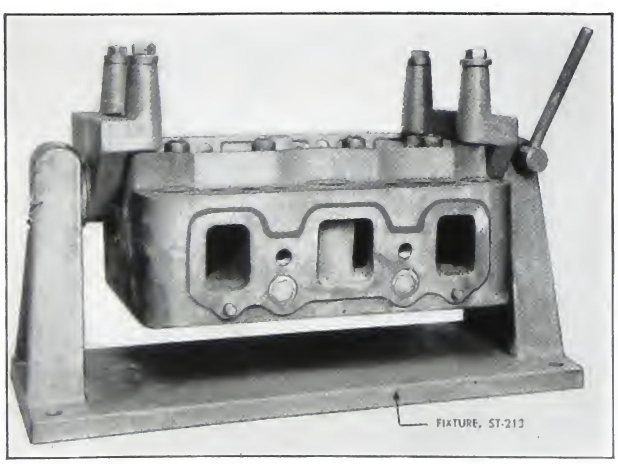

Fig. 3-8. Cylinder head holding fixture

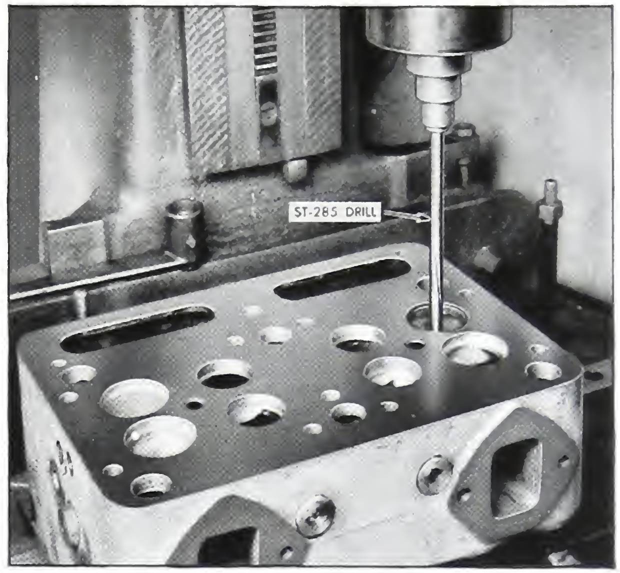

Fig. 3-9. Reaming valve guides

Check size with a new crosshead stem and, if there is any binding, ream the guides to .3755/.376 with a bottom reamer.

INJECTOR SLEEVES: 1. All cylinder heads before engine Serial No. 88757 have a chamfer at the bottom of the injector sleeve bore to permit the injector sleeve to be sealed by a flare on the milled side of the cylinder head. This bore is no longer chamfered on cylinder heads after the above number; on these heads, the injector sleeve seals in the bore taper, and the sleeve is not flared at the bottom.

INJECTOR SLEEVE INSTALLATION: Flared Sleeve: 1. Use ST-200 anvil and swaging punch to drive in and seal the lower end of the injector sleeve. Assemble the sleeve in the head by driving it solidly against the seat with the anvil of ST-200 and a soft hammer. Tighten the anvil on the injector studs to approximately 15 foot pounds tension. See Fig. 3-10.

2. Use the 45° angle punch of ST-200 to turn the lower end of the sleeve before using the 60° punch. Light blows on the punch with an 8 oz. plastic hammer will be sufficient.

3. Finish sealing the lower end of the sleeve with the 60° angle punch. (Fig. 3-11).

4. Finish by removing excess material with a mill file, flush with the milled face of the head.

5. Seal the upper part of the sleeve into the cylinder head with ST-296 expanding roller tool.

This tool is used like any flue roller. As the roller is turned, increase tension against the rollers by the center tapered mandrel until the copper injector sleeve is sealed tightly into the cylinder head. See Fig. 3-12.

6. The upper part of the injector sleeve must be 1.570 to provide clearance for the injector body. Continue the rolling operation until this diameter is obtained. The tapered mandrel can be marked to stop at this diameter.

NOTE: The injector sleeve must not protrude above the bore. This would prevent the injector from sealing. If it does protrude after rolling is completed, it must be cut back with an end cutter.

7. Insert ST-438 seating cutter in a drill press to cut the injector seat in the newly installed sleeves. (Fig. 3-13). This cutter is designed to cut a true seat for the injector cup and, at the same time, cut a .010 relief in the bottom section. Correspondingly, the injector cup seal is made near the top of the cup taper where the supporting metal of the cylinder head is stronger.

8. Take a very light cut to prevent chattering. Cut just deep enough so that the tip of the assembled injector protrudes through the cylinder head .040/.055.

Non-Flared Sleeve: 1. To install injector sleeves on latest type cylinder heads without the countersink in the sleeve bore, the anvil of ST-200 is used only to drive the sleeve in the bore a distance sufficient to permit ST-384 hold-down tool to be fastened in place.

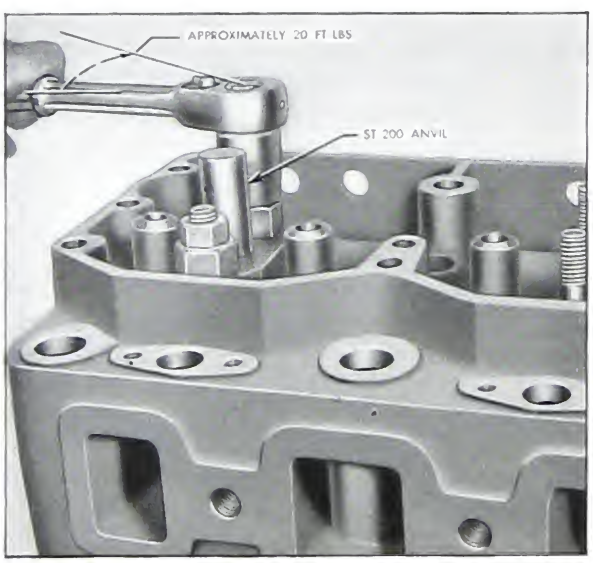

Fig. 3-10. Sealing lower end of the injector sleeve "A"

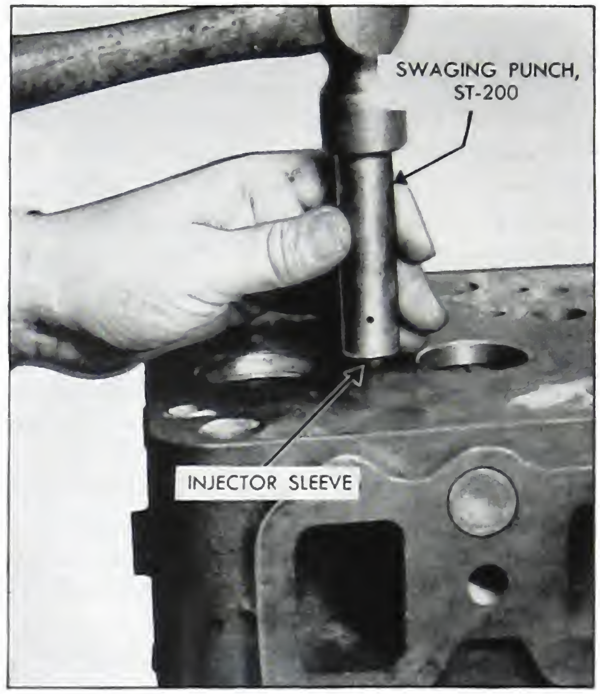

Fig. 3-11. Sealing lower end of the injector sleeve "B"

2. Tighten the nut against the spacer of the hold-down tool until the sleeve comes in firm contact with the seat in the cylinder head.

3. Use ST-296 expanding roller tool as described in the previous paragraphs.

4. Remove ST-384 hold-down tool and use a piloted spotfacing cutter, ground to 54 degrees included angle to countersink the protruding end

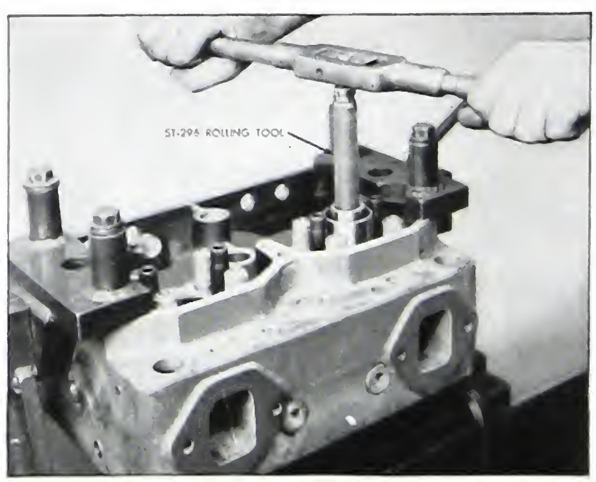

Fig. 3-12. Sealing upper end of injector sleeve

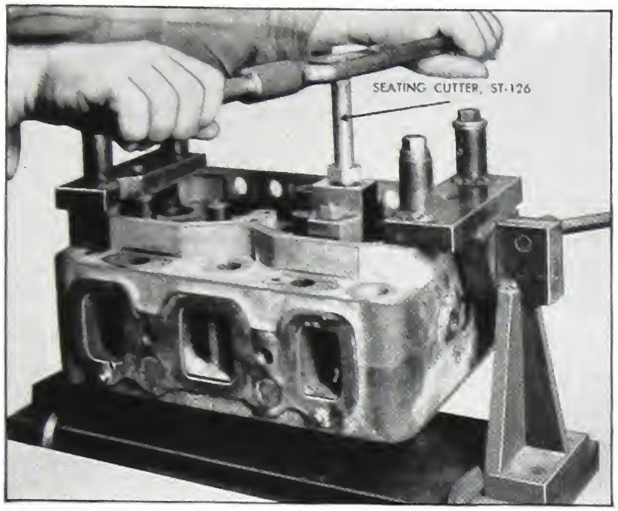

Fig. 3-13. Facing injector seat

of the sleeve to the point where the outside diameter of the sleeve is flush with the cylinder head milled surface.

CAUTION: BE VERY CAREFUL NOT TO CUT INTO THE CYLINDER HEAD WHILE DOING THIS OPERATION.

5. Use ST-438 seating cutter, as previously described to face the injector sleeve for injector cup seal.

VALVE SEATS: 1. If inspection has shown that valve seat inserts are loose, or if valve seats are wider than .125 and can not be narrowed sufficiently as shown in Fig. 3-17, new valve seat inserts should be installed. Remove old valve seat inserts with a valve seat puller or with a punch through the ports.

2. Cummins service tools are available for installation of new valve seat inserts. The counterbore must be enlarged for the next oversize. Cutters are available in sets—standard and various oversizes—for each engine:

a. ST-259 for H heads.

b. ST-260 for NH heads.

3. ST-257 Valve Seat Insert Tool is needed to hold and drive the cutters. This tool must be driven by an electric motor. See Fig. 3-15.

NOTE: In place of ST-257 tool a slow-speed heavy-duty drill press can be used as a driver for the cutters.

4. Counterbores for valve seat inserts should be machined .006 to .010 deeper than the insert height to permit peening of head to hold insert. Set tool or press for exact depth of cut.

5. A peening tool is included in Tool Kit, ST-257. In place of the peening tool, a 1/4 inch diameter round-end punch can be used. Avoid over-swaging around the insert: this may cause a cast iron ring to be broken from the cylinder head.

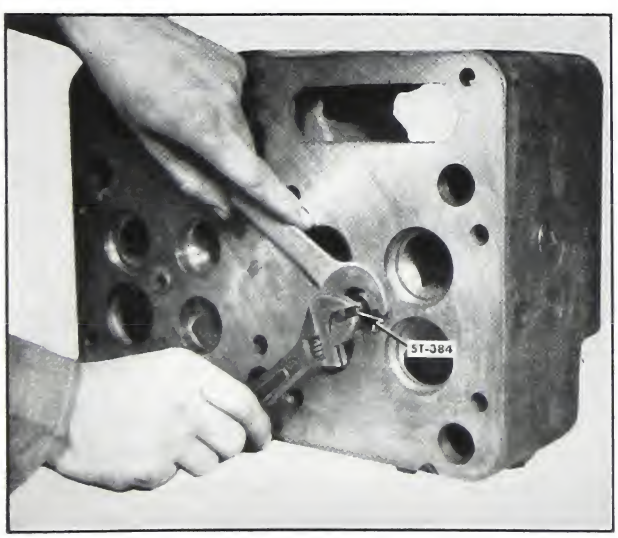

Fig. 3-14. ST-384 hold down tool

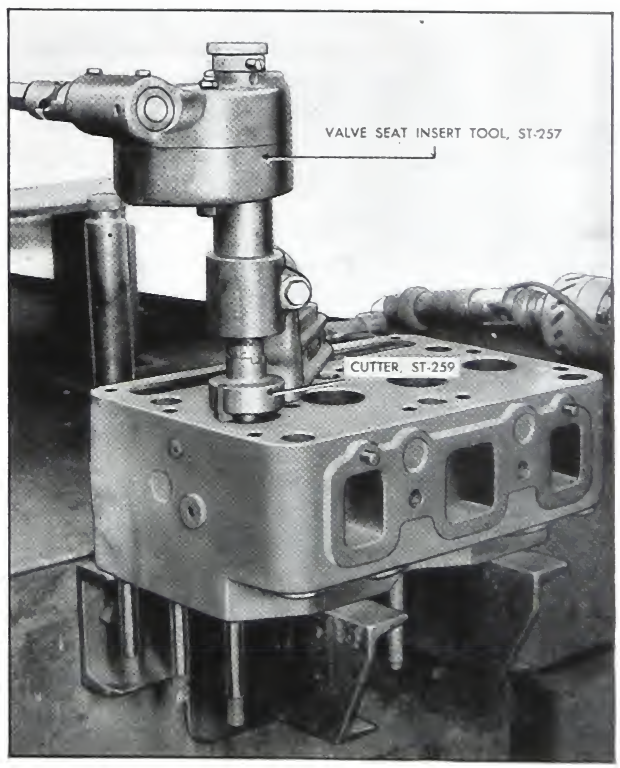

Fig. 3-15. Counterboring head for valve seat insert

TABLE—VALVE SEAT INSERTS

Part No.	Engine	Oversize Dia.	Oversize Depth	Insert O. D.	Cylinder Head I. D.	Insert Thickness
70650	H	Std.	Std.	2.1280/2.1275	2.1255/2.1245	.258-.256
70650-A	H	.005	Std.	2.1330/2.1325	2.1305/2.1295	.258-.256
70650-B	H	.020	.005	2.1480/2.1475	2.1455/2.1445	.263-.261
70650-E	H	.030	.010	2.1580/2.1575	2.1555/2.1545	.268-.266
70650-C	H	.040	.015	2.1680/2.1675	2.1655/2.1645	.273-.271
69965	NH	Std.	Std.	1.847/1.846	1.8440/1.8435	.281-.279
69965-A	NH	.005	Std.	1.852/1.851	1.8490/1.8485	.281-.279
69965-B	NH	.020	.005	1.867/1.866	1.8640/1.8635	.286-.284
69965-C	NH	.030	.010	1.877/1.876	1.8740/1.8735	.291-.289
69965-D	NH	.040	.015	1.887/1.886	1.8840/1.8835	.296-.294

6. Cummins Engine Company, Inc., furnishes stellite valve seat inserts in standard, .005, .020, .030, and .040 oversizes for all 4⅞ x 6 and 5⅛ x 6 engines.

Grind Valve Seats: 1. To obtain good valve seats, the following conditions must be achieved:

a. There must be no grind or reamer marks on seating surfaces and within the guide.

b. The valve face must be ground to a true 30 degree angle and concentric with the guide area of the valve stem.

c. The valve seat face must be ground to a true 30 degree angle. Width of grind must be within limits, and seat must be concentric to the reamed valve guide.

d. Valve guide-to-stem clearance must be within the limits determined from correct stem and guide dimensions as shown in Table, "Valve and Guide Data", Page 3-4.

2. Make sure the valve seat grinding equipment is in good condition. Mandrels must be straight and of proper size to fit in reamed valve guides. The bushing in the grinder must be clean and a close fit on the mandrel. Bearings must be in good condition. Precision work is not easy with worn-out equipment.

3. Dress the stone to 30 degrees from the horizontal. Hold seating motor as nearly vertical as possible. Even though the grinder has a universal joint, holding it at a severe angle will cause the seat to be out-of-true depending upon the amount of wear in the grinder bearings, mandrel, bushings, etc. See Fig. 3-16.

4. Ground seat faces should be held between 1/16 inch and ⅛ inch width and, preferably, nearer the low figure.

5. If ground seat is wider than maximum ⅛ inch, stock can be removed from points "A" and "B" with specially dressed stones in a valve seat grinder. Narrowing should not extend beyond the chamfer that is provided for peening. See Fig. 3-17.

6. Dress the wheel for the final finish. Finish grind with light touches of the stone against the face.

7. After valve seats are finish ground, check guide alignment with eccentrimeter as shown in Fig. 3-18. The gauge must be a perfect fit on the pilot mandrel. Run-out should not exceed .001 inch.

NOTE: In order to understand the importance of correct tightening of injector hold-down nuts, repeat the above check with an injector in place and the hold-down nuts tightened to 10 to 12 foot pounds. There should be no deflection of valve seats; however, if nuts are over-tightened, the perfectly ground seats will be distorted. OVER-TIGHTENING INJECTOR HOLD-DOWN NUTS IS ONE CAUSE OF CRACKED CYLINDER HEADS AND VALVE TROUBLES.

Grind Valves: 1. Check your valve grinder. The machine can be checked easily by using a new valve and an indicator gauge.

2. Chuck the valve on the guide area of the stem. The guide area holds the valve in its working position. The relieved portions on both ends of the guide area are not necessarily concentric to the guide area of the stem.

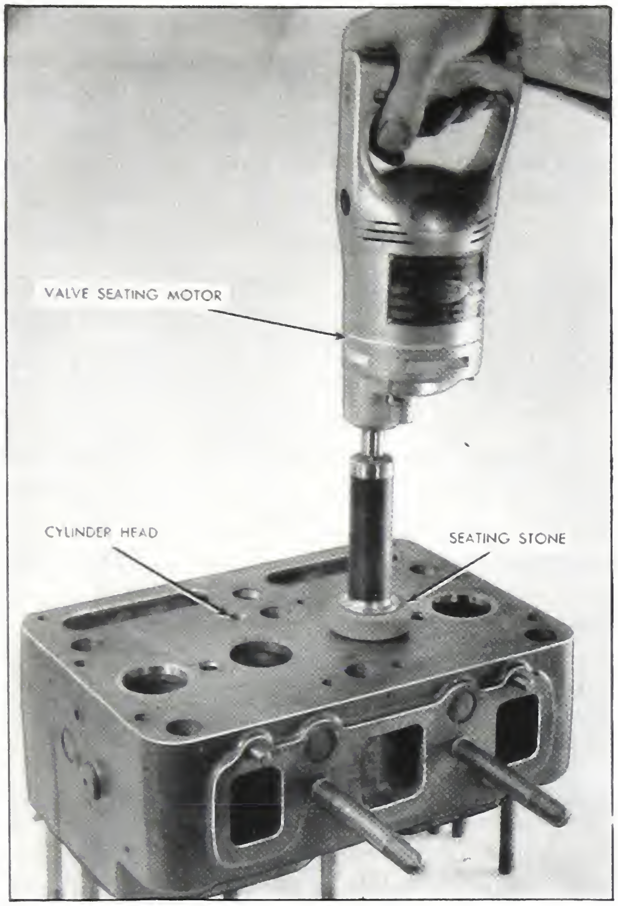

Fig. 3-16. Refacing valve seats

3. With the new valve chucked in the machine, and the indicator point on the ground face, turn the valve and mark the high spot on the head of the valve. Loosen the chuck and rechuck the valve 180° from the first position, and again mark the high spots.

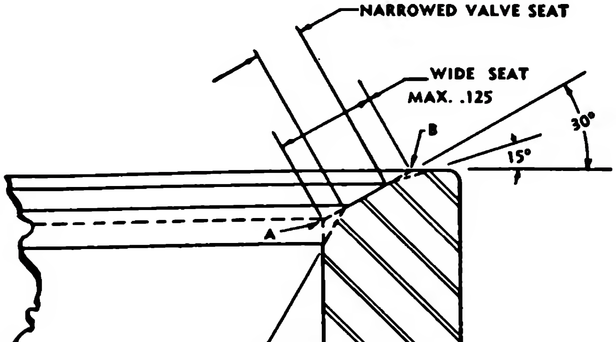

Fig. 3-17. Cross section valve seat insert

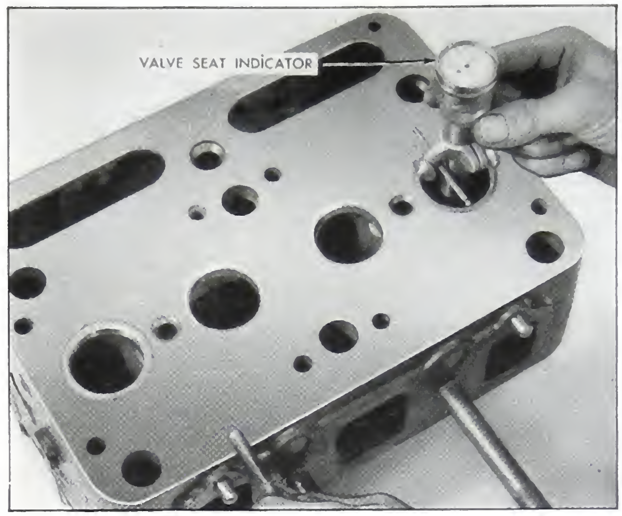

Fig. 3-18. Checking valve seat

4. If the high spots are the same for both positions, the valve is warped. If they occur in different positions, the chuck is out of alignment. Run-out should not exceed .001 inch.

5. Bearings of the machine must be in good condition and wheel must be proper grade and well dressed to avoid chatter and grind marks.

6. Grind valves to exact 30° angle from horizontal. Use a well dressed wheel and wet grinding for a good finish. Wet grinding also helps prevent burning while grinding.

7. A well ground finish is far superior to lapping. Lapping the valve to a valve seat makes small grooves which are true only when the engine is cold. After the engine is warmed up, different degrees of expansion make the lapping useless. The lapped surfaces no longer coincide. On the other hand, a well ground and polished valve will be in contact during all degrees of expansion. Lapping, if done at all, must follow the best possible grind job and it must be held to a minimum. Only the finest grade of compound should be used to prevent grooving of seats.

8. After grinding, check the rim thickness as shown in Fig. 3-19. If the rim is thinner than 1/16 inch there is danger of burning and cupping.

9. Indicate the newly ground valve face or check in finish reamed guide against newly ground valve seat face as shown in Fig. 3-20. Rotate the valve only 10 degrees to remove pencil marks or very thin coating of Prussian blue.

10. A true seat will be indicated if all pencil

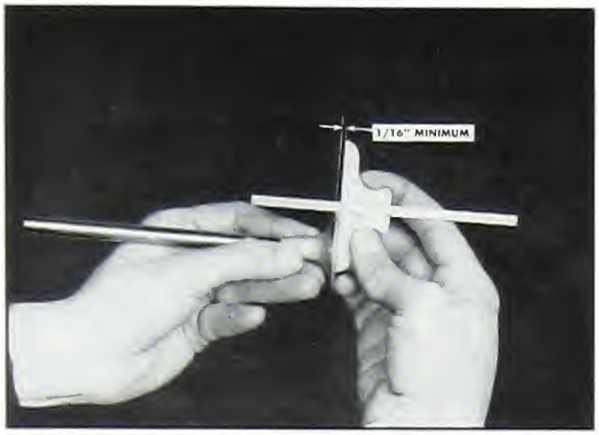

Fig. 3-19. Checking thickness of valve head rim

marks are broken. If pencil marks are not broken, the valve seat tools need dressing or the machine has not been properly adjusted.

VALVE SEAT TESTER: The valve seat vacuum tester ST-417 is the most positive of all tests to determine if valves are properly seated and should be used at all time. All Cummins Dealers have this tester or if you do your own cylinder head rebuilding they can obtain a tester for you. Following are the instructions for use of the ST-417 Valve Seat Tester:

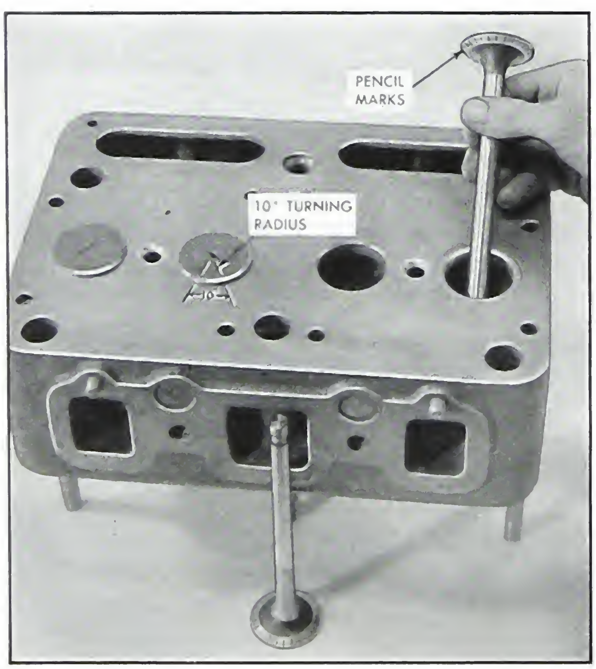

Fig. 3-20. Checking valve seat and valve

1. Testing must be performed after valves and seats are ground and valves assembled, with springs, in the cylinder head. Valves and seats are to be dry and clean. *Do not install the injectors.*

2. Connect the tester to its source of power, some testers operate from 6 volt batteries, others from 110 volt electrical outlet.

3. Place the suction cup over the valve head. Grease can be applied to the "O" ring to provide a better seal to the head surface. *Keep the valve and seat dry.*

4. Turn the hand shut-off valve to open position, and hold the push button down to operate the vacuum pump. Fig. 3-21.

5. Operate the vacuum pump until the hand on the vacuum gauge stops climbing. This should be 15 to 25 on the scale.

6. Close the shut-off valve and release push button to stop the pump. The suction cup should be held to the head by vacuum.

7. Time the fall of the gauge hand to test the valve seal. If the hand falls back, time from the time the hand reaches 15 and until it reaches 12, if less than 10 seconds the valve seal is unsatisfactory.

8. When seal is unsatisfactory first check the tester connections or to see if the valve and seat are dirty, then regrind valve and seat as necessary.

NOTE: To check tester connections, perform above operations on a smooth surface. If the hand falls there is a loose connection.

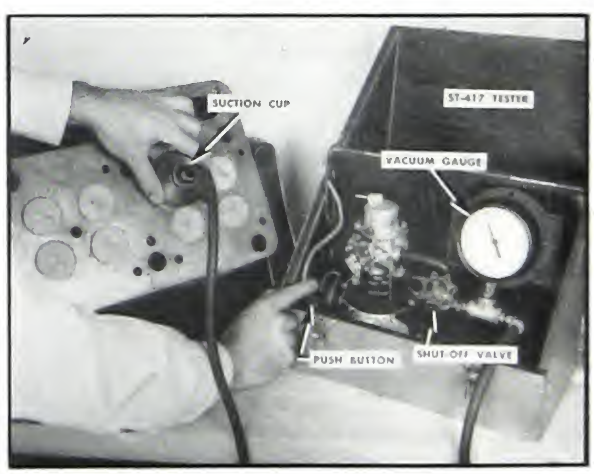

Fig. 3-21. Using the ST-417 tester

9. It is possible to mistake leakage around the valve seat insert for valve leakage. If this is suspected, apply grease around the outside edge of the insert, making a grease seal. Perform the above test and check for a break in the grease seal. If there is a break the insert leak should be corrected.

EXPANSION PLUGS: 1. Replace all expansion plugs either with expansion plugs or pipe plugs. If expansion plugs are used, the counterbore should be cleaned and the plugs driven in with plug sets from Tool Kit ST-190.

2. If pipe plugs are installed, the plugs must be the shallow countersunk type and installed so the water passages will not be blocked and so the plugs will not interfere with the use of engine lifting hooks.

WATER TEST: Test the rebuilt cylinder heads for water leakage in a test fixture at a pressure of 35 to 80 pounds per square inch with dummy injectors installed.

PAINT: Repaint the cylinder heads. New paint not only makes the head look better but provides protection and a means of identification.

ASSEMBLE VALVES AND SPRINGS: 1. Assemble the valves and properly calibrated valve springs to the cylinder heads. Use new half collets, if the old ones are worn, to secure the valves and springs.

2. Use spacers under the springs to compensate for the extended lengths caused by grinding to bring the compressed length in valve position to 2 11/16″ for Model H and 2¼″ for the NH valve springs.

VENT AND BREATHER HOLES: 1. All stud holes in the cylinder head have vent holes to prevent rusting of studs from condensed water vapor. Make sure that these holes are open.

2. At the top of the cylinder head and between the center stud holes is a breather or vent hole. On all H and NH cylinder heads this breather hole must be open. HS and NHS cylinder heads must have this hole plugged with a ⅛″ Allen pipe plug. See Fig. 12-1.

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SECTION IV

UNITS NO. 3 AND NO. 4

Rocker Levers

Cam Followers

CLEANING, DISASSEMBLY AND INSPECTION

Steam clean all cam follower housings and levers, rocker lever housings and levers, and rocker lever housing covers.

Immerse all parts in these groups except the aluminum covers in the solvent tank and leave until clean.

Rocker Lever Housing And Levers

1. Remove the set screw that holds the rocker arm shaft in the housing.
2. Remove the expansion plug at each end of the housing. Use a sharp pointed punch to drive through the plug on one end and drive the shaft through to force the second expansion plug out of the housing.
3. Gauge the rocker lever bushings with telescoping inside gauge and micrometers. See Fig. 4-2. New or newly bored bushings should gauge 1.1245 to 1.1255. If they are worn beyond the limit of 1.1265 at any point, they should be marked for rebushing. ST-194 is plug gauge for checking new bushings, but it will not detect uneven wear.
4. The ball end of rocker lever adjusting screws must be true spheres. Test them with a ¼" radius gauge. If worn flat, they must be replaced.
5. The injector rocker lever sockets must be replaced, if worn. Wear is easily detected by a radius gauge or by the small protrusion at the bottom of the socket. These sockets must seal with injector links in the assembled engine to prevent loss of lubricating oil to the fuel oil drain.
6. No. 41698-1 shaft is a smooth shaft. It should replace the old style grooved shaft. When this change is made, the position of the lock screw must be changed to the under side of the housing as shown in Fig. 4-4.
7. Check to see that all lubricating oil passages are open and unobstructed.
8. Any play of rocker lever rollers on pins is cause for replacement of pins. Rollers must be replaced if worn flat at any point or if the pin hole is worn beyond .346. Pins and rollers can be removed by grinding the peened end of the rivet and pressing out the rivet and pins with punches.
9. If NH valve rocker levers are old style with lubricating hole open on the end of the lever, this must be welded closed and a new 1/16" drilled hole made back of the stellite insert on the under side.
10. Rocker levers must not be used if bored holes for roller pins are distorted enough to throw the roller out of alignment with the shaft bushing.

Push Rods

1. The ball of a new fuel push rod is .748/.749 diameter and is ground to true spherical contour. If the end of the ball is worn flatter than .500 radius, it should not be used. In fact, worn balls should never be installed in sockets of new cam follower levers. Valve push rod ball is .625 O.D.

2. The lift or collar of intake push rods must not be so badly worn that there is danger of its not functioning with the compression release lever.

3. Test the sockets of push rods with the ball end of a new rocker lever adjusting screw, or with 1/4" radius gauge.

4. Extreme wear on either end of the push rod will result in loss of lubricating oil pressure and may interfere with proper valve and injector adjustment.

Cam Follower Housing And Levers

1. Remove the set screws that hold the shafts in the housing. (Fig. 4-1).

2. Drive out the expansion plugs. Use a punch to drive through one expansion plug; then drive the shafts from the housing.

3. If the shafts are worn smaller than .748, replace them with new style ungrooved shafts.

4. Gauge cam follower lever bushings. (Fig. 4-2). New, or newly replaced and bored bushings, must gauge .7495 to .7505. If old bushings are worn larger than .7515, the levers must be rebushed with new style two-piece bushings. The two-piece bushings must always be used in combination with the new-style ungrooved shafts.

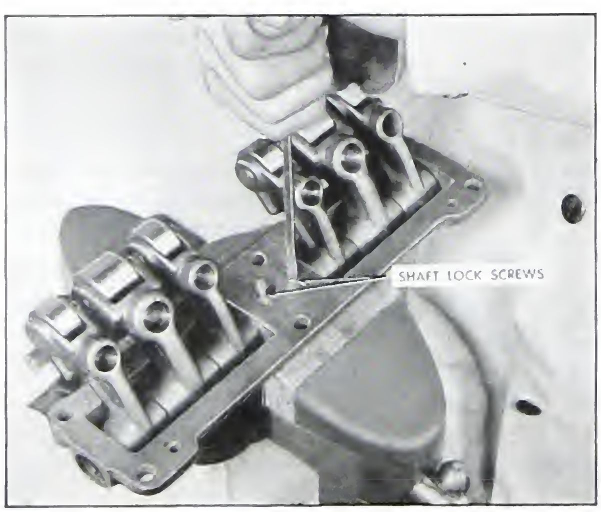


Fig. 4-1. Shaft lock screws

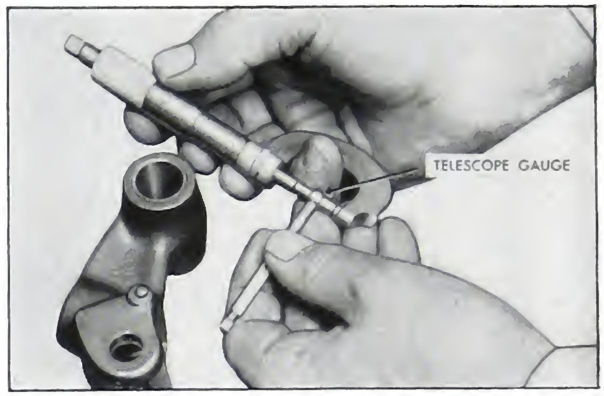


Fig. 4-2. Gauging cam follower bushing

5. Use a dial indicator depth gauge across the milled face of the housing, with shafts in place, to determine that the cam follower lever shafts are parallel to the milled surface of the housing. A variation of approximately .015 will make a difference in engine timing of 1°.

6. Cam follower lever socket wall thickness must be at least .070 at the thinnest spot on levers that are to be reinstalled. This can be measured with transfer type calipers as shown in Fig. 4-3. The tool shown is Federal Model No. 49T-172.

NOTE: Latest cam follower levers have a removable seat. These must be replaced if scored or extremely worn. Check with a new push rod ball and Prussian Blue.

7. If cam follower lever pins are worn smaller than .497, they must be replaced.

8. Cam follower lever rollers should be replaced if (a) scored (b) worn with flat spots (c)

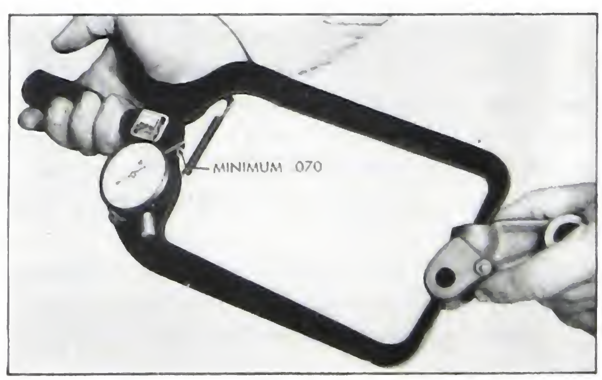


Fig. 4-3. Gauging worn wall of lever

worn smaller than 1.247 O.D. or (d) worn larger than .505 I.D. Worn rollers, or rollers not in alignment with camshaft, cause extremely fast wear of the camshaft lobes.

MAGNETIC INSPECTION: 1. Used rocker levers and cam follower levers, in particular, should be checked by magnetic inspection for surface imperfections and cracks.

2. The resulting damage caused by a broken cam follower lever and a loose push rod is often very serious.

3. Magnetic inspection by the wet method used in conjunction with a fluorescent black light reveals any fatigue crack or surface imperfection that would be almost impossible to detect visually.

4. Thoroughly clean the levers of all dirt, oil and grease before checking.

5. Check the levers both longitudinally (between centers) and circumferentially (in a coil) at approximately 1200 amperes current. Any crack appears as a bright yellow line. See Fig. 4-4.

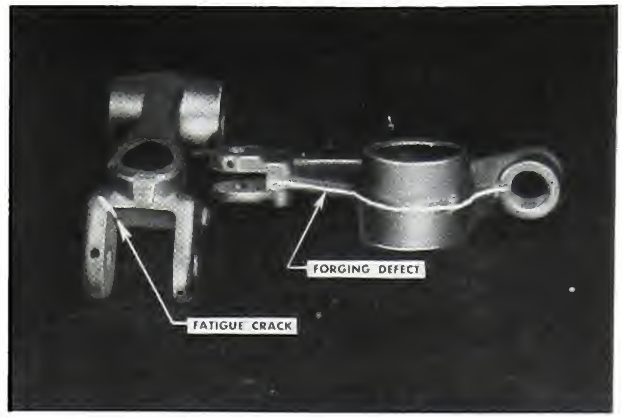


Fig. 4-4. Magnetic inspection of rocker levers

6. Reject any lever showing a crack or imperfection.

REBUILDING

Rocker Levers And Housing

ROCKER LEVER HOUSING: 1. Grooveless, 41698-1, rocker lever shafts should be installed in all NH rocker lever housing assemblies. If the housing has not been used with this shaft, it will be necessary to relocate the shaft locking set screw hole as detailed in Steps 2 to 9 inclusive.

2. Scribe a line, "A", above the rocker arm shaft in line with the center of the oil pipe bore and the center of the hold-down stud bore as shown in Fig. 4-5.

3. Scribe an intersecting line in line with the center of the rocker arm shaft hole, "B", as shown in Fig. 4-5.

4. Measure 5/16" from the intersection on line "B". Center punch for location of new lock screw hole.

5. Drill through to the shaft hole with an "F" (.257) drill.

6. Tap through with a 5/16"-18 N.C. tap.

7. Counter drill 5/32" deep with a 5/16" drill.

8. Use rocker lever shaft set screw, No. 67283, and rocker lever shaft lock plate, No. 67282, to hold the shaft in its proper position.

9. An ear of the lockplate should be bent up against one of the flat hex sides of the set screw to lock it in position.

10. Although this drilled hole is not necessary on rocker lever housings used on Model H engines, it is being put in all housings, 3491-1 and 2362-1, to keep them interchangeable. When used on Model H engines, the tapped hole should be plugged to prevent possible escape of lubricating oil from the grooved shaft and hole. This would result in lowered oil pressure. Use S-110 (5/16" x 5/8") capscrew and 67282 lock plate to plug the hole.

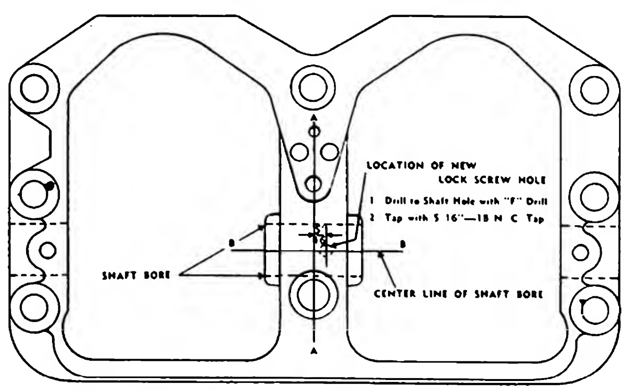


Fig. 4-5. Rocker arm housing—top view

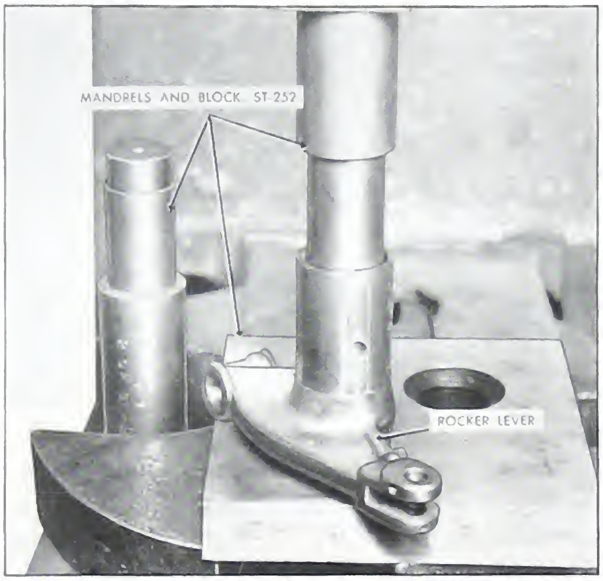


Fig. 4-6. Pressing bushing in rocker lever

REBUSH AND BORE ROCKER LEVERS: 1. If inspection has shown that the rocker lever bushings should be replaced, press out the old bushings with mandrel and block, ST-252.

2. Check with compressed air to make sure the lubricating oil passages are open.

3. Use mandrel and block, ST-252, in an arbor press to install new bushings in the levers as shown in Fig. 4-6. The sleeve will support the bushing and prevent distortion of the bushing during this operation. Use the hole in the sleeve to align the hole in the bushing with the lubricating oil boss of the lever. This will index lubricating oil drillings in bushing and lever.

4. Use a 60° angle cutter in a slow speed drill press to chamfer each end of the bushings in the levers. DO NOT CUT INTO THE LEVER.

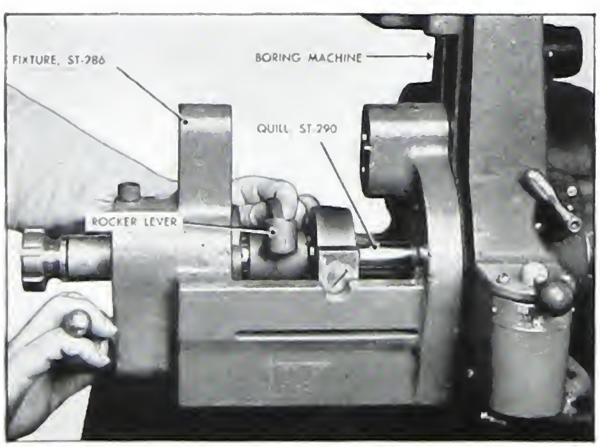


Fig. 4-7. Boring rocker lever bushing

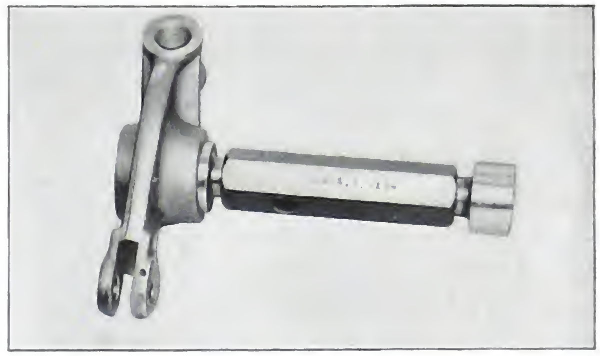


Fig. 4-8. Gauging bored rocker lever bushing

5. Put semi-soft soap in the lubricating hole of the bushings. This will prevent chips from entering oil passages during the boring operation.

6. Assemble the lever on the proper locating mandrel of the boring machine. Lock lever in position with clamp and remove mandrel. Bore bushing to 1.1245-1.1255. (Fig. 4-7).

7. Check the size of the bored bushing with plug gauge ST-194. (Fig. 4-8).

8. Blow the soap from the lubricating oil holes.

Cam Follower Levers

REBUSH AND BORE CAM FOLLOWER LEVERS: 1. Remove old, worn cam follower lever bushings with mandrel and block, ST-249.

2. Check oil passages with compressed air to make sure they are open.

3. Later style cam follower lever bushings are made in two pieces leaving a space between the bushings for the oil well and permitting the use of the smooth cam follower lever shaft. The old style grooved shaft can be used with the two piece bushings, but the new style grooveless shaft can not be used with old style, drilled, single piece bushings.

4. Press the bushing halves in the lever from either side, flush with the lever, with mandrel and block, ST-249, as shown in Fig. 4-9.

5. Use a 60° angle cutter in a slow speed drill press to chamfer each end of the bushings in the levers. DO NOT CUT INTO THE LEVER.

6. Put semi-soft soap in the lubricating holes

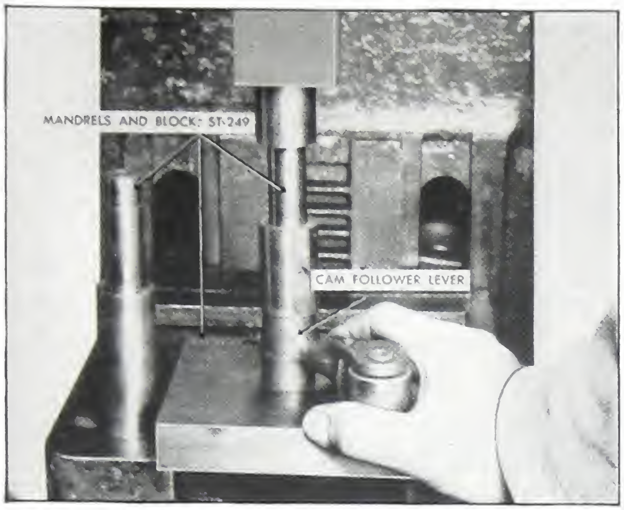


Fig. 4-9. Pressing bushing in cam follower lever

of the bushing to prevent chips from entering the oil passages during the boring operation.

7. Change boring fixture and tool of boring machine to accommodate cam follower levers for line boring 3.009 to 3.010 between roller pin and

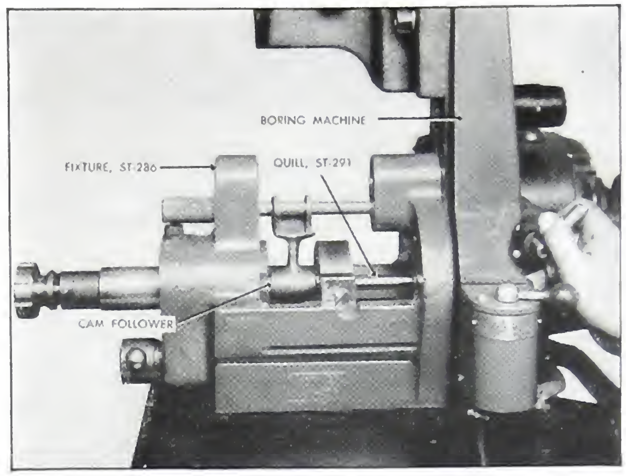


Fig. 4-10. Boring cam follower lever bushing

shaft centers. Bore bushings to .7495/.7505. (Fig. 4-10).

8. Check bored bushings with plug gauge, ST-195.

9. Blow soap out of lubricating oil holes.

ASSEMBLY

Rocker Levers And Housing

1. Use new parts, or parts not worn excessively, as indicated by inspection and procced with assembly as directed in following paragraphs.

2. Assemble jam nuts and adjusting screws to rocker arm levers.

3. On Model H series only, install rollers and roller pins and rivet in place with new rivets. USE SMALL RIVETING PUNCH TO AVOID DISTORTION OF ROLLER PIN HOLE. Only the exhaust rocker lever is drilled for lubrication to the rollers.

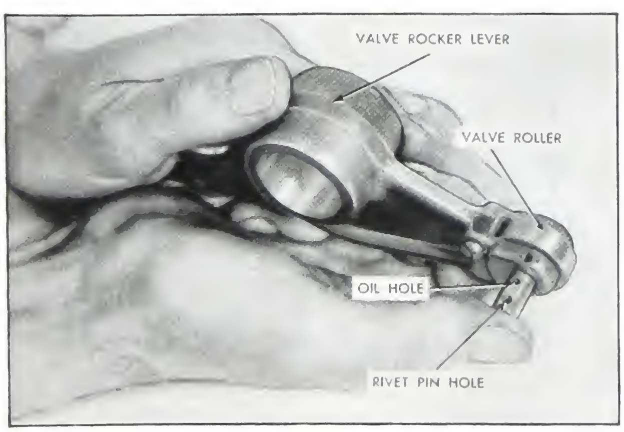


Fig. 4-11. Assembling rocker lever roller pin

4. Assemble injector rocker lever sockets in levers.

5. Assemble the levers in the housing and push the rocker lever shaft in place. (Fig. 4-12). Use grooveless shaft in NH series assembly.

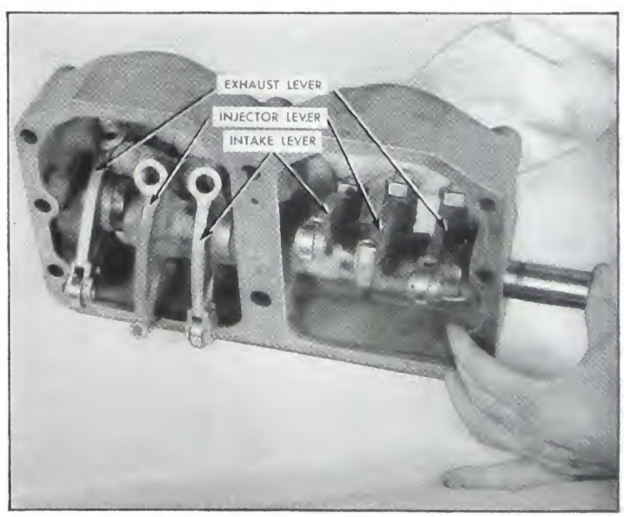


Fig. 4-12. Upper rocker housing

6. Install and tighten lock screw to hold the shaft.

7. Install new expansion plugs in each end of the housing.

8. Install circlips between rocker levers.

Cam Follower Levers And Housing

1. If the push rod ball socket has been removed, press in a new socket, making sure it is securely seated. These cam follower levers were used in all H and NH engines after Serial No. 115173.

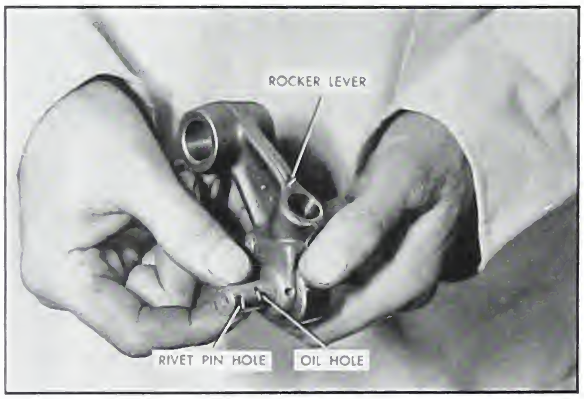


Fig. 4-13. Assembling cam follower roller pin

2. Assemble new pins to rollers in position. (Fig. 4-13.)

3. Drive pins through rollers and levers, and rivet in place.

4. Assemble levers and shafts in position, with the injector lever in the center of each assembly. (Fig. 4-14.)

5. Assemble shaft lockscrews.

6. Install new expansion plugs at each end of the shaft seating into bore of bushing.

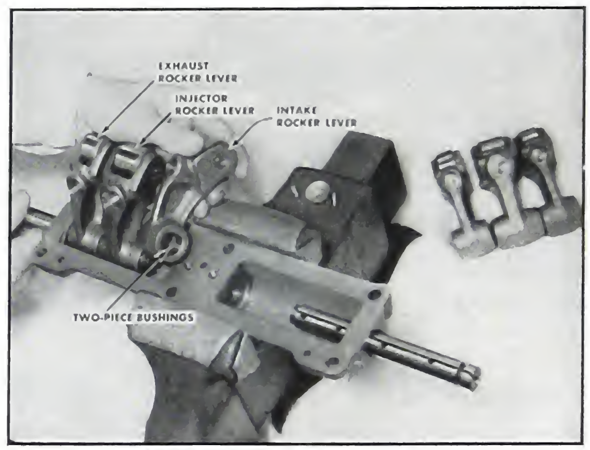


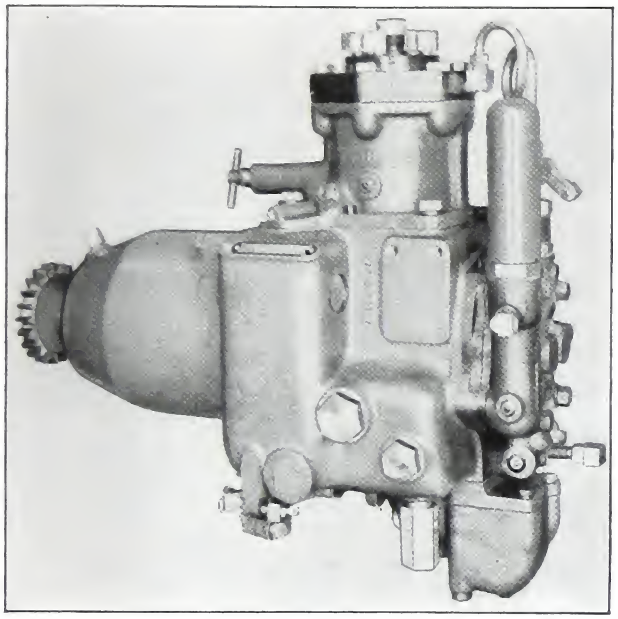
Fig. 4-14. Assembling cam follower housing

SECTION V

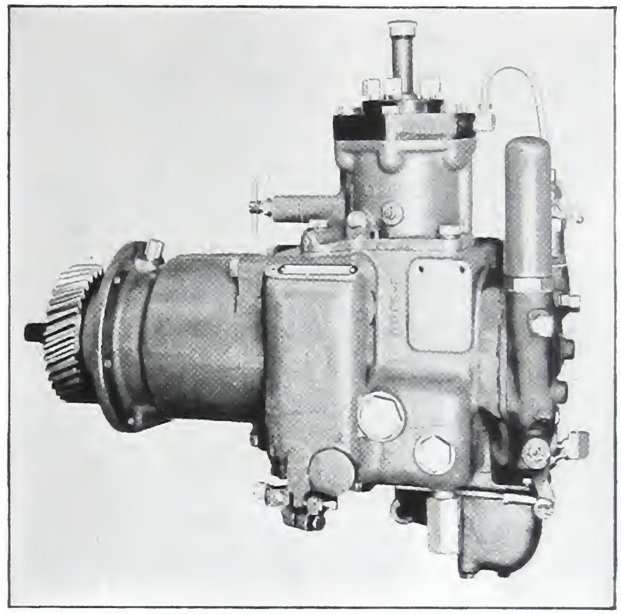
UNIT NO. 5

Fuel System—Pumps and Filters

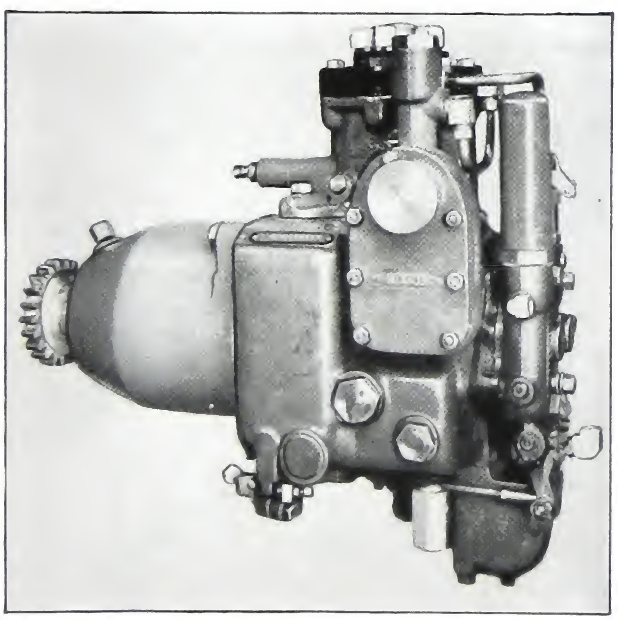
SINGLE-DISC FUEL PUMPS



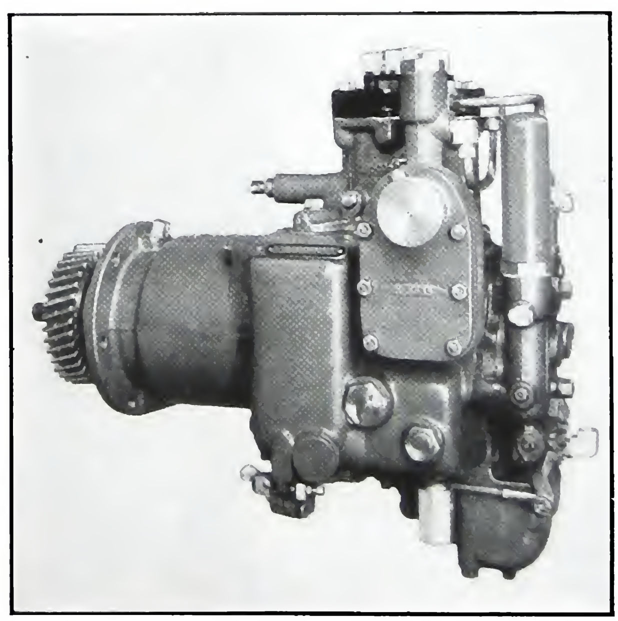
Compressor type



Less compressor type



Compressor type with overspeed stop

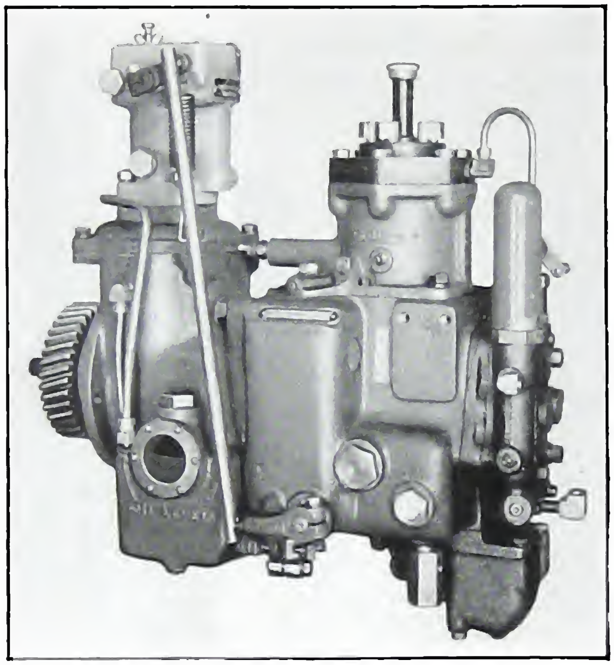


Less compressor type with overspeed stop

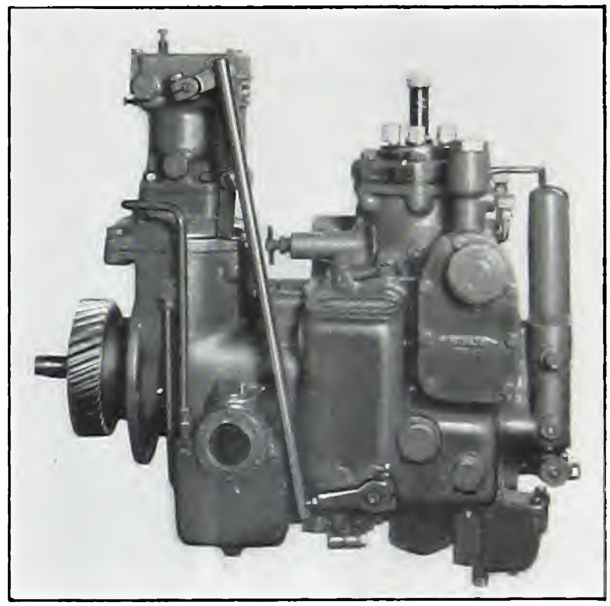
Fig. 5-1a. Fuel pumps with mechanical governors for H and NH series engines

Fuel pumps for Cummins Models H and NH series engines are supplied with either mechanical or hydraulic type governors.

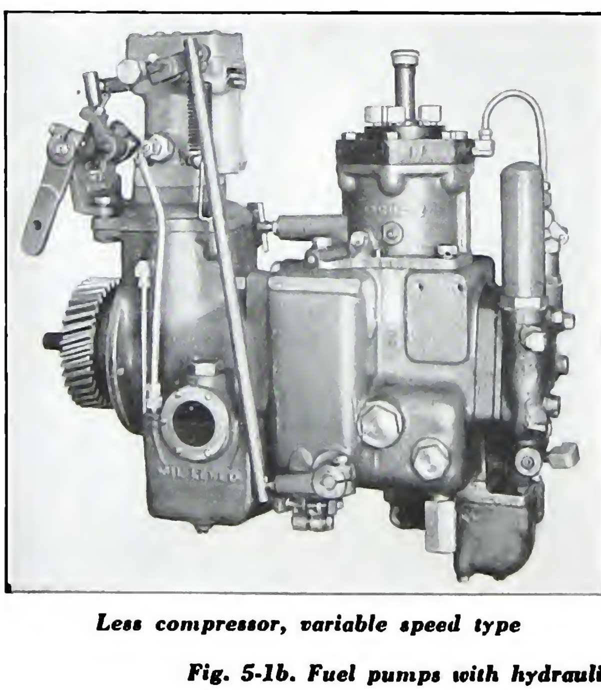
The fuel pump with mechanical type governor may be either compressor type or less compressor type. The compressor type is made with governor housing and drive coupling to allow installation of an air compressor between the fuel pump and the gear case portion of the cylinder block. The less compressor type pump mounts to the gear case so the main drive gear is meshed directly with the engine camshaft gear.



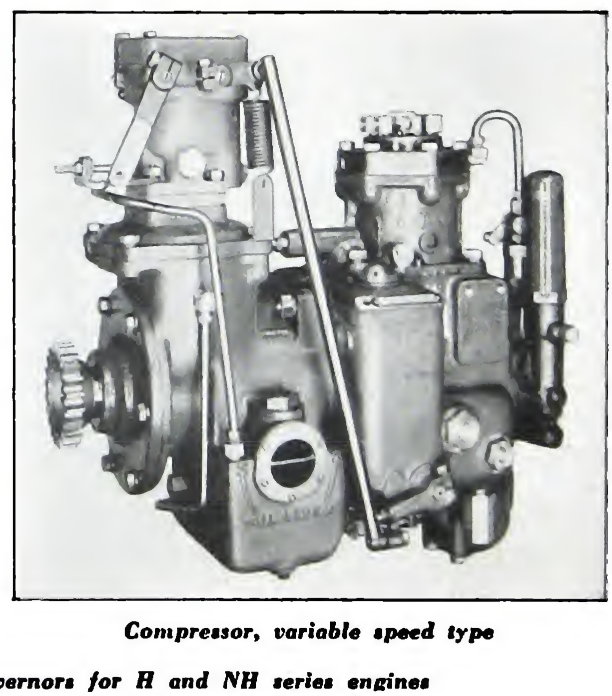
Less compressor, constant speed type



Less compressor, constant speed type with overspeed stop



Less compressor, variable speed type



Compressor, variable speed type

Fig. 5-1b. Fuel pumps with hydraulic governors for H and NH series engines

Fuel pumps equipped with hydraulic governors are supplied with either constant speed or variable speed controls. Overspeed stops may or may not be used with either type governor.

Two fuel pumps, the less compressor type mechanical governor controlled, and the constant speed hydraulic governor controlled with overspeed stop, will be treated in this rebuild manual.

For the sake of brevity, all reference applicable only to mechanical governor controlled fuel pumps will be under the heading **"Mechanical"** and those applicable only to hydraulic governor controlled pumps will carry the heading **"Hydraulic"**.

REMOVAL OF UNITS AND CLEANING

Single-Disc Fuel Pump

DRAIN FUEL PUMP: 1. Disconnect and remove all the fuel lines from the pump. Drain the float chamber.

2. Disconnect and remove the tachometer shaft cable, if used.

Hydraulic: 3. Drain the lubricating oil from the sump in the governor drive housing.

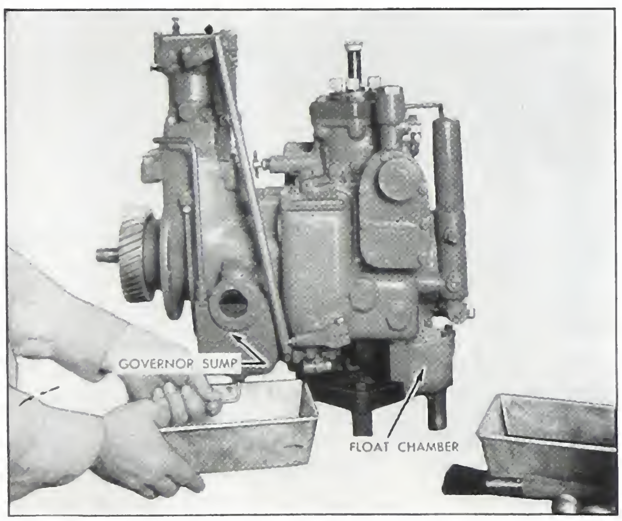


Fig. 5-2. Draining lubricating oil

STEAM CLEAN: 1. Plug all fuel inlet and discharge holes in the fuel pump.

2. Steam clean the exterior of the pump.

HOLDING FIXTURE: 1. A suitable holding fixture should be provided to receive the fuel pump. The fixture should revolve on a pivoted joint and the pump should be bolted to it at the bracket holes of the main housing. The separate pump units can then be removed or repaired from the main housing.

2. The fixture shown is ST-120. If it is desired, a swivel mounting plate can be made and attached to the angle plate so the pump can be revolved 360° in either direction.

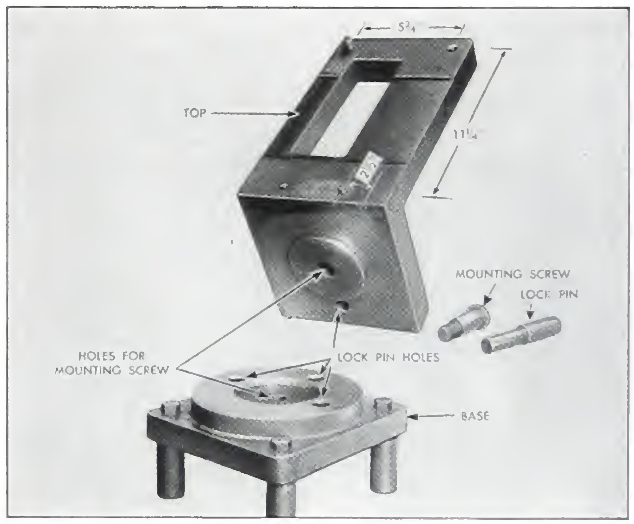


Fig. 5-3. Fuel pump holding fixture

OVERSPEED STOP: 1. Remove the seven mounting capscrews and lockwashers from the cover. Lift off the cover and gasket.

2. Remove the pawl and spring.

3. With a heavy-duty screw driver remove the four fillister head screws and lockwashers. Lift the assembly from the fuel pump. Fig. 5-4.

DISTRIBUTOR: 1. After removing the capscrews that hold the distributor housing to the main housing, lift the distributor housing, shaft and gear from the main housing.

2. Before removing the distributor housing completely from the main housing, remove the metering plunger and spring to prevent its falling out and being damaged.

GEAR PUMPS: 1. Remove the cam rocker lever

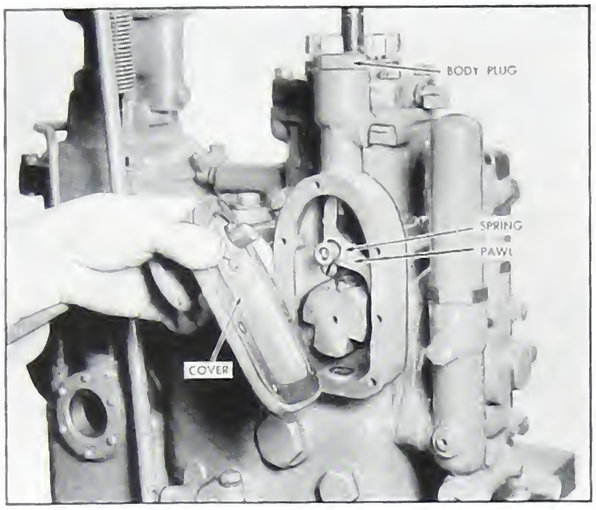


Fig. 5-4. Overspeed stop cover plate

spring retainer and spring from the side of the fuel pump housing. This is the larger of the two hexagon head screws on the front of the housing.

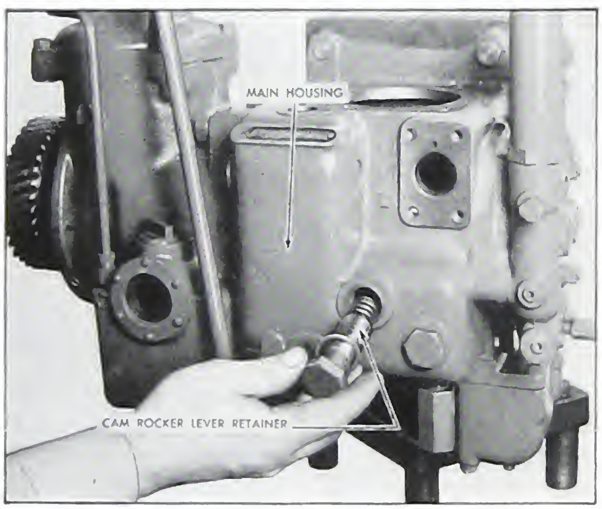


Fig. 5-5. Cam rocker retainer

2. Remove the four capscrews holding the gear pump bodies to the main housing. (Do not remove the three nuts from the bolts at this time.)

3. Pry the gear pump assembly from the dowel pin and, while holding to the pressure chamber and the idling control lever, pull the gear pump assembly from the main housing. Fig. 5-6.

NOTE: Some operators bolt brackets to the gear pump. This should not be done because of the danger of distortion and gear pump failure.

FLOAT CHAMBER: Remove the two capscrews

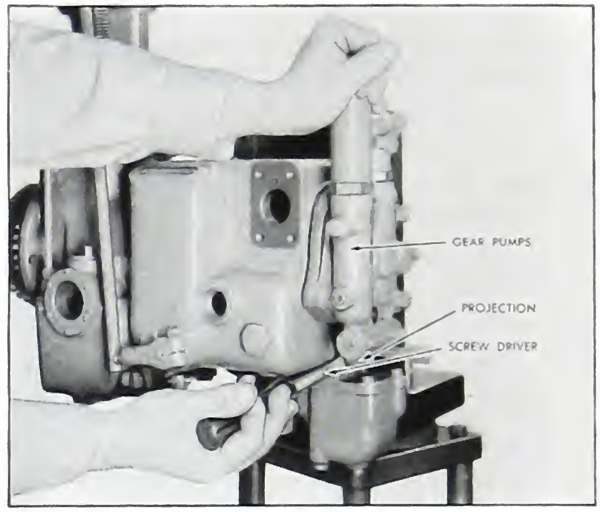


Fig. 5-6. Removing gear pumps

holding float chamber to the fuel pump housing. Remove the float chamber from the housing.

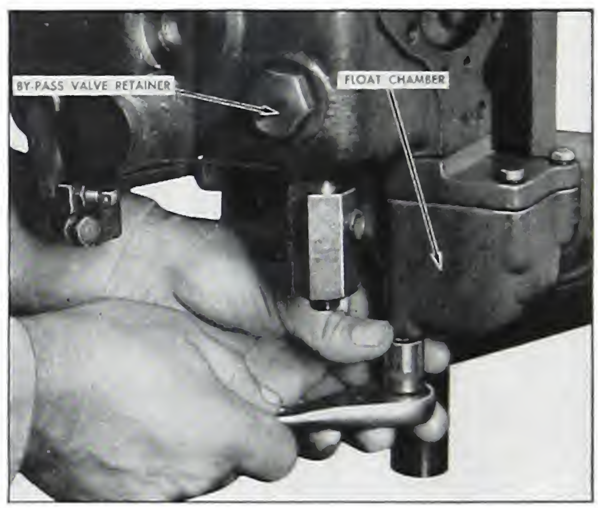


Fig. 5-7. Removing float chamber

HYDRAULIC GOVERNOR AND DRIVE UNIT —Hydraulic: 1. Disengage the governor opposing spring from the spring clip.

2. Remove the control link from the governor terminal lever and the governor control lever.

3. Loosen the capscrew from the lever clamp on the long terminal shaft and remove the terminal control lever and spring.

4. Disconnect and remove the lubricating feed oil line from the governor and oil sump connections.

5. Remove the four capscrews and lockwashers from the adapter plate.

6. Loosen the adapter plate by tapping on the

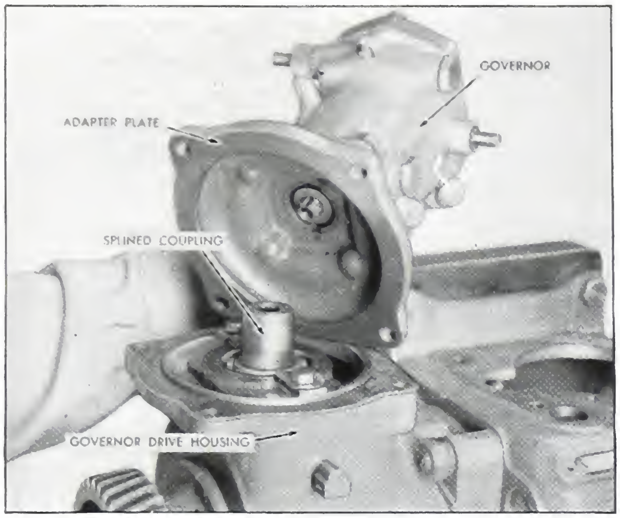


Fig. 5-8. Removing governor and adapter plate

bottom side with a rawhide or lead hammer and lift the governor, adapter plate and gasket from the governor housing. See Fig. 5-8.

7. Remove the splined coupling from the splined governor drive shaft.

8. Straighten the lock plates with a hammer and punch. Loosen the two capscrews until the retainer can be removed to clear the ball bearing retainer on the governor drive unit.

9. Drive through the expansion plug on the back side of the governor drive housing with a punch and remove the expansion plug.

10. With a long, heavy-duty screwdriver inserted through the expansion plug hole, pry up against the nut on the governor shaft to remove the governor drive unit from the governor drive housing. If the governor drive unit will not pry off easily, use a back hammer with ¼″-20 thread screwed into the splined shaft to loosen the unit.

GOVERNOR DRIVE HOUSING AND MAINSHAFT: 1. Use a puller to remove the fuel pump drive gear from the main drive shaft as shown in Fig. 5-9. If the shaft has been scored, it may be advisable to protect the end of the shaft with a threaded sleeve when using the puller. A hydraulic ram will effect some time saving in this operation.

2. Remove the nuts and lockwashers from the studs holding the governor drive housing to the main housing and slip the governor drive housing from the stud bolts. (Fig. 5-10).

3. Remove the four capscrews and lockwashers from the bearing shield.

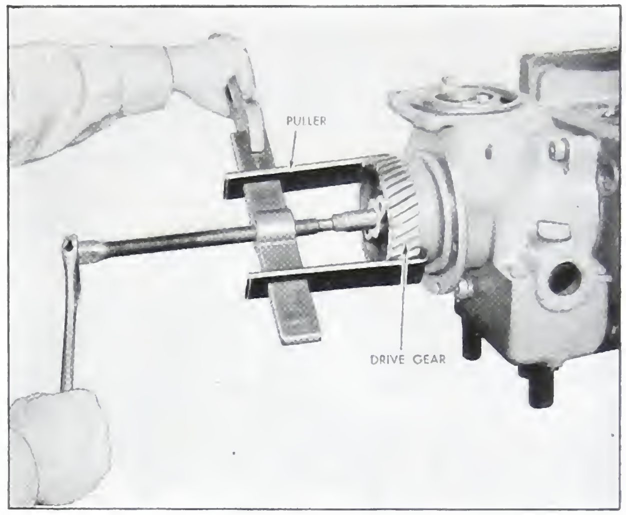


Fig. 5-9. Pulling fuel pump drive gear

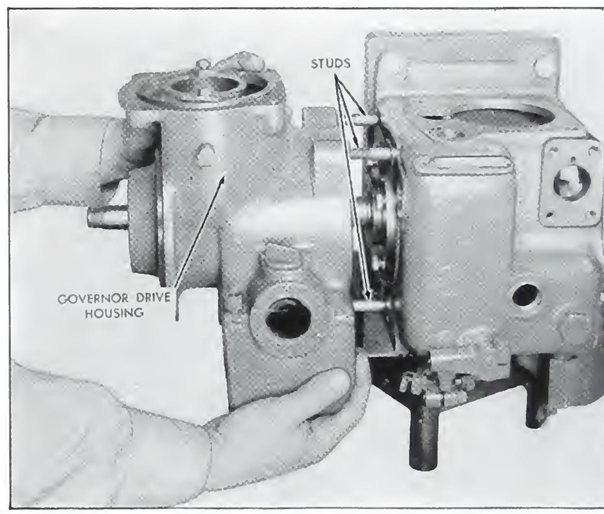


Fig. 5-10. Removing governor drive housing

4. Push the cam rocker lever down to clear the distributor drive gear on the main shaft. Tap the end of the main shaft with a soft hammer and remove the shaft assembly from the main housing. Fig. 5-11.

CAUTION: TAP SQUARELY AGAINST THE SHAFT TO AVOID DAMAGE TO THE BALL BEARING.

GOVERNOR HOUSING AND MAINSHAFT—Mechanical: 1. Remove the hex nut and lockwasher from the drive gear end of the main shaft, and remove the drive gear with a suitable puller.

2. Remove the three capscrews and lockwashers that hold the governor housing to the main housing, and take off the governor housing.

3. Using an end wrench, disconnect the small

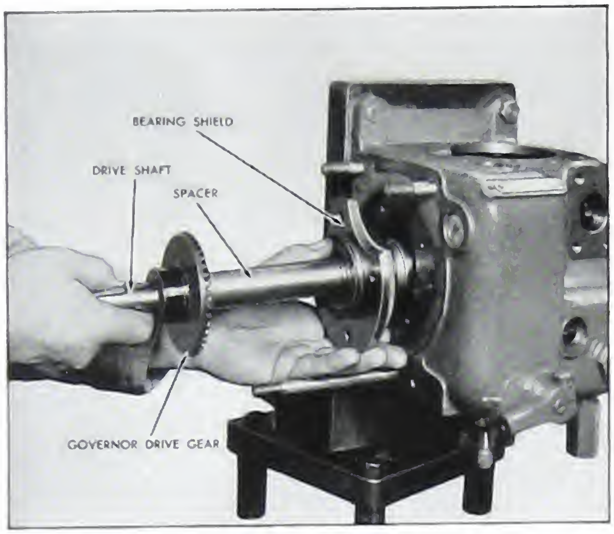


Fig. 5-11. Main shaft and bearing shield

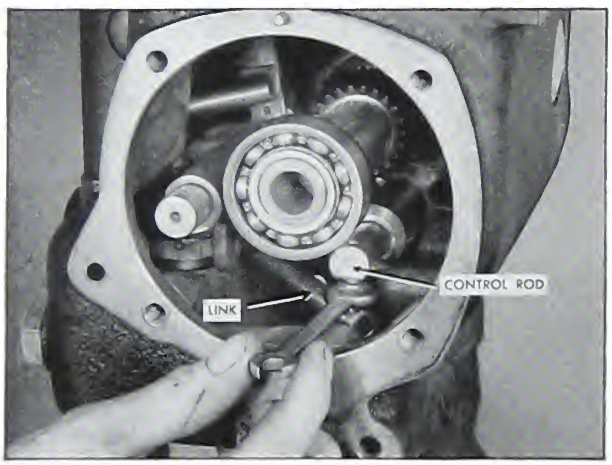


Fig. 5-12. Governor link and control rod

ball joint screw from the governor control rod as shown in Fig. 5-12.

4. Remove the four capscrews from the governor ball bearing shield. Drive the governor and main shaft out of the main housing from the gear pump end of the shaft.

MAIN HOUSING—Hydraulic: 1. Loosen the capscrew from the clamp of the governor control lever and remove the governor control lever, Woodruff key and spacer from the control shaft.

2. Use a small wrench to disconnect the ball joint on the short vertical lever link from the vertical lever.

3. Insert a socket wrench through the hole in the top of the housing to loosen the capscrew which holds the plunger lever shaft and plunger lever pin in place. Fig. 5-13.

4. Drill a $\frac{1}{4}''$ hole through one expansion plug and punch the shaft with a small punch to

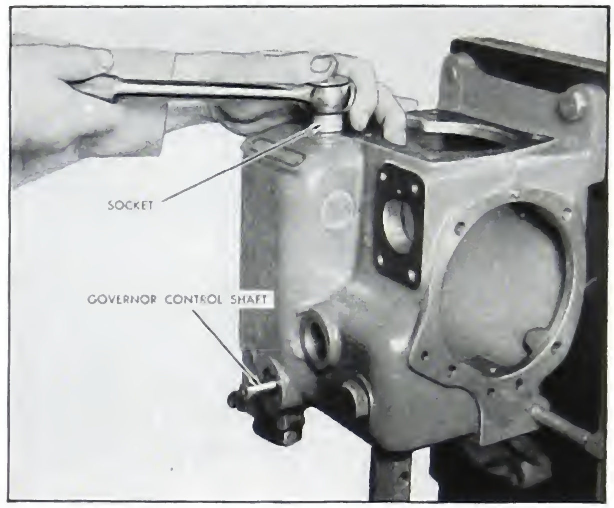


Fig. 5-13. Loosening capscrew in plunger lever

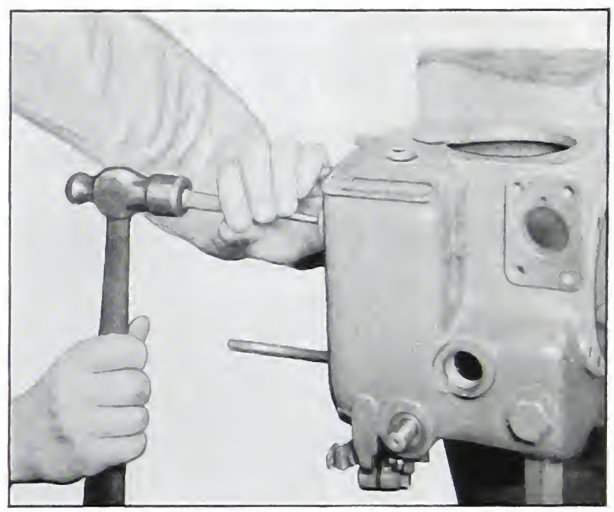


Fig. 5-14. Driving out expansion plugs

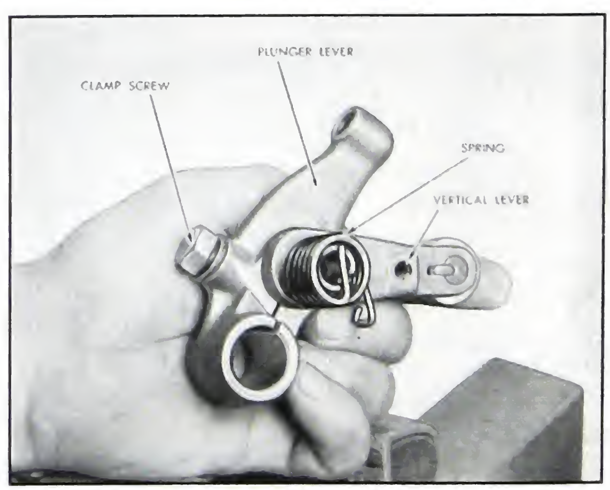


Fig. 5-15. Vertical lever assembly

knock out the second expansion plug. Fig. 5-14.

5. Lift the vertical lever assembly from the housing. Fig. 5-15.

CLEANING OF PARTS: 1. Immerse the following parts and assemblies in the hot solvent tank to rcmove all sludge and dirt:

Main Housing
Governor Housing
Mainshaft Assembly

2. Clean all other fuel pump parts in mineral spirits tank at the bench.

DISASSEMBLY, INSPECTION AND PARTS REPLACEMENT

OVERSPEED STOP—Disassembly: 1. Grasp the lower part of the body in a vise with copper jaws.

2. Remove the body plug and gasket from the housing.

3. Lift out the valve spring and valve.

4. Remove the nut and lock plate from the drive shaft.

5. Hold the gear between copper jaws of a vise and, using a copper punch, drive the shaft and body from the gear.

6. Remove the cotter key, collett, spring and weight from the drive shaft.

Inspection: 1. Inspect the drive gear. If the teeth show wear, this gear and the matching gear on the fuel pump drive gear must be replaced.

2. Check the overspeed stop drive shaft. When new, the dimension is .5615/.561. Ordinarily, the wear on this shaft is very slight and replacements uncommon, but if it is worn to less than .560 it should be replaced.

3. Test the fit of the valve in the body. It must work freely but fit closely. A poor fit would cause sticking of the valve or leakage of fuel into the housing. If the valve leaks excessively, it will be necessary to replace both valve and housing with a new assembly.

4. Check the valve seat with Prussian blue. Unless the seat is good, the overspeed stop will not completely shut off the fuel supply. Mark for valve grinding, if needed.

5. Check the overspeed stop shaft bushings, No. 62371-S. The inside diameter of these bushings when new is .562/.563. If worn to more than .564, press them out and get new bushings.

6. Inspect the overspeed stop pawl and replace new, if it shows wear on the end that comes in contact with the weight sufficient to endanger tripping action.

7. Check the overspeed stop reset shaft and replace, if worn.

8. Provide new oil seal and all new gaskets.

9. Three overspeed stop weight springs are supplied in combination with different weights and spacers to provide correct tripping speed. Tripping speed can be determined accurately on the fuel pump test stand. Refer to "Spring Data" Page 14-9 for spring identification.

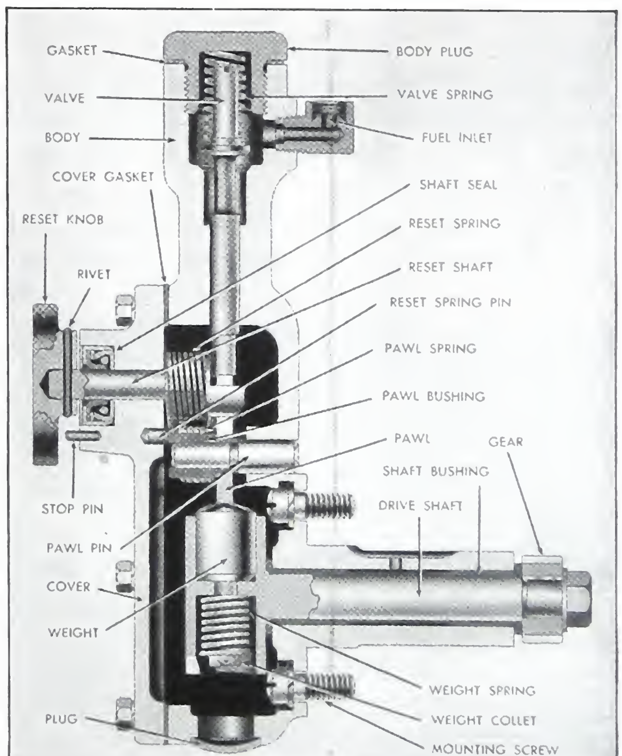


Fig. 5-16. Cross section of overspeed stop

DISTRIBUTOR—Disassembly: 1. Six capscrews hold the distributor cover to the housing. Remove all but two opposite capscrews and then remove the last two by loosening them one-half turn at a time to maintain an even spring pres-

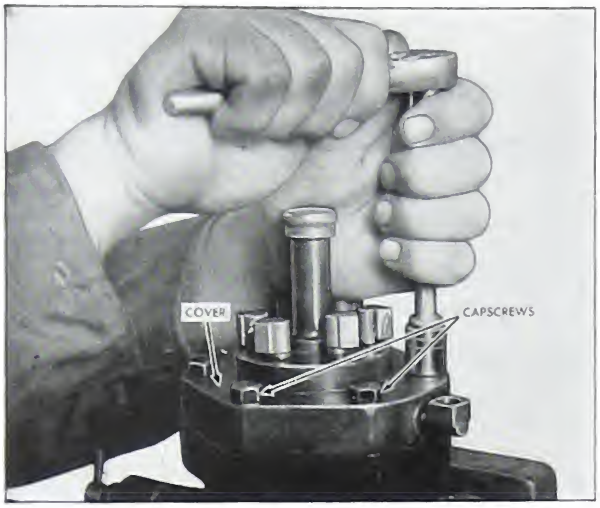


Fig. 5-17. Distributor cover

sure and prevent the distributor disc from catching in the distributor bushing and scoring the bearing surfaces.

2. Lift the disc cover up far enough to insert one hand under the disc and remove the disc and cover together. The film of oil will hold the disc to the cover until the hand can be inserted.

CAUTION: NEVER LAY THE FACE OF THE DISC OR COVER ON ANYTHING BUT CLEAN CLOTH OR CLEAN PAPER. EVEN A SMALL SCRATCH OR DIRT MAY CAUSE FUTURE TROUBLE.

3. Wash each part in solvent as removed and dry with compressed air. Clean all fuel passages

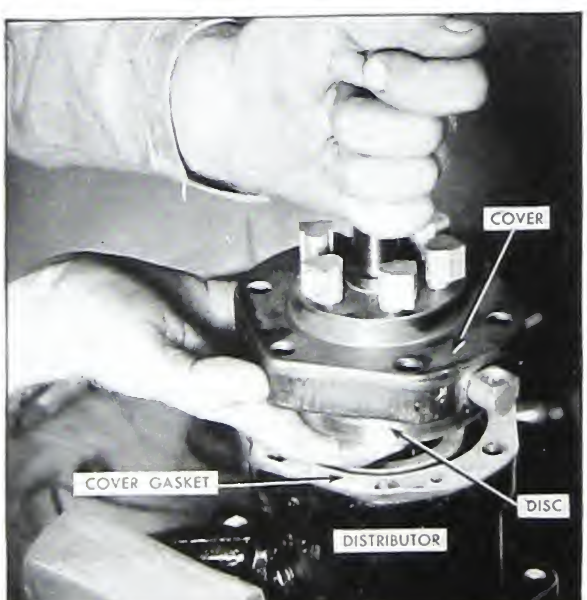


Fig. 5-18. Lifting out distributor disc and cover

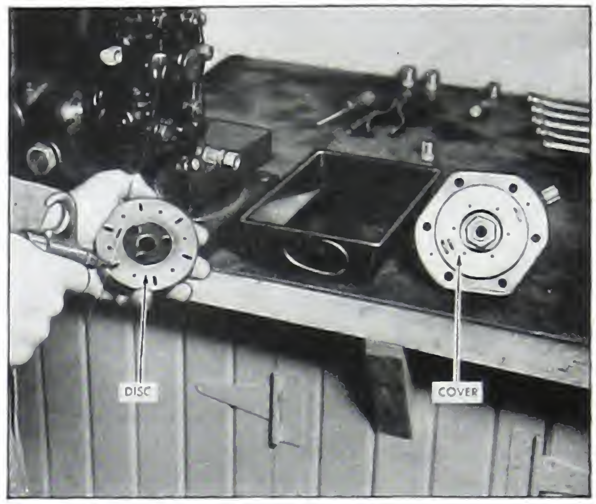


Fig. 5-19. Cleaning distributor disc and cover

in the distributor disc and cover with compressed air.

4. Remove the distributor spring from the housing.

5. Clamp the housing in a vise by gripping the edges as shown in Fig. 5-22. Remove the metering plunger and barrel after unscrewing the retaining nut.

6. Remove the priming valve from the side of the housing and check the point to see that it has not been broken from overtightening. If it has been broken, remove all the particles from the housing. If a particle of the priming valve is stuck in the housing it can be removed as follows:

a. Assemble the distributor cover to the housing 60° (one hole) off location so the fuel passages are sealed.

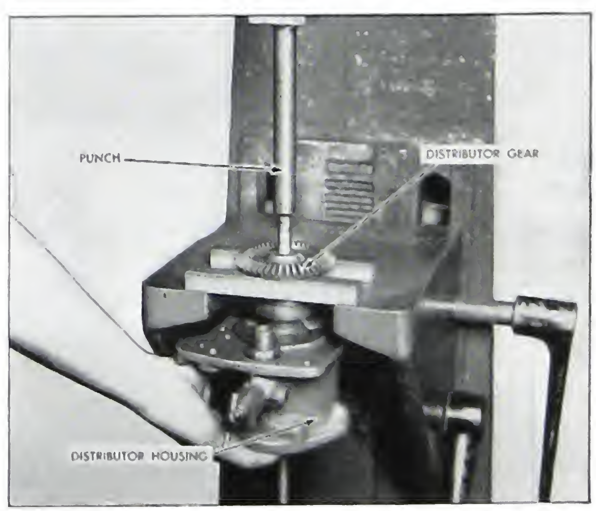


Fig. 5-20. Removing distributor drive gear

b. Assemble the metering pump to the housing and partly fill the metering pump barrel with 600 W grease.

c. Put the housing in an arbor press and ram the metering plunger downward. The hydraulic pressure will force the broken particle out of the housing.

CAUTION: AVOID INJURY BY POINTING THE PRIMING VALVE BOSS AWAY FROM ANY WORKMEN.

7. Press the gear from the distributor shaft, being careful to support the gear close to the shaft to prevent warping the gear. Remove the Woodruff key from the shaft. Fig. 5-20.

8. Tap the lower end of the distributor shaft on a block of wood or drive out with a hammer and copper punch. Remove the shaft and collar from the housing. Fig. 5-21.

9. Remove the double ball bearing from the lower end of the housing.

10. Remove the distributor check valve screw, spring and ball.

CAUTION: IT IS VERY IMPORTANT THAT THE VISE JAWS BE COVERED WITH COPPER WHEN ANY MACHINED SURFACES ARE HELD IN THE VISE.

Inspection: 1. Inspect the metering plunger and barrel for wear or scratches. If either part is worn, it will result in a loss of pressure and inaccurate metering to the injectors. A good test for the fit of the plunger is to close off the barrel with the finger and test the suction. The plunger should be held by suction, while dry, for at least one minute.

2. The priming valve seat must be concentric

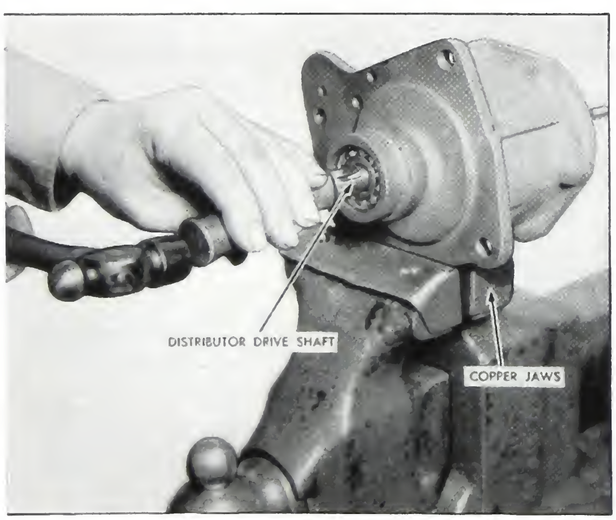


Fig. 5-21. Distributor drive shaft

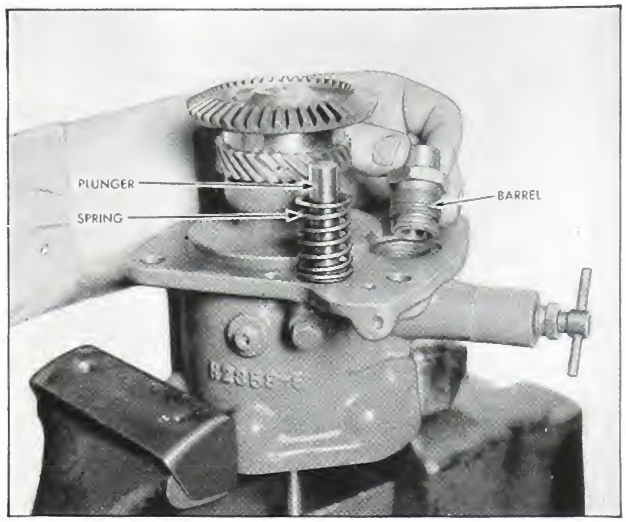


Fig. 5-22. Metering pump parts

with the bore to insure a perfect seal for the fuel oil from the priming passage. Any leakage of fuel past the priming valve would allow unmetered fuel to be delivered to the injectors, which, in turn would cause dangerous engine speeds. Test seat with Prussian blue.

3. The distributor check valve regulates fuel oil pressure lubrication of main housing parts. If the spring is too weak or if the ball check does not seat properly, it will interfere with proper delivery of fuel to the metering pump. The check valve spring, No. 65506, should compress to 1.000 inches at 1.638 pounds. Its breaking point is 85 psi in assembly.

4. Inspect the distributor drive collar and shaft. If the shaft is worn in the thrust bearings, fuel will leak by the shaft to fill the main housing and run out the overflow. If the shaft is worn beyond the limit of .810 or if the distributor drive collar is worn or scored, the collar and shaft must be replaced as an assembly. New shaft diameter is .8105/.811. Distributor disc drive pins must hold the disc with no appreciable "play".

5. The worn limit for replacement of the distributor shaft bushing is .814. New reamed bushings should gauge .812/.813. The distributor collar should seat on entire circumference and on at least 75% of top surface of the distributor shaft bushing to make an effective seal. Check the finished seat with Prussian blue.

6. Inspect the overspeed stop drive gear, if used. If it shows uneven or excessive wear, mark it for replacement.

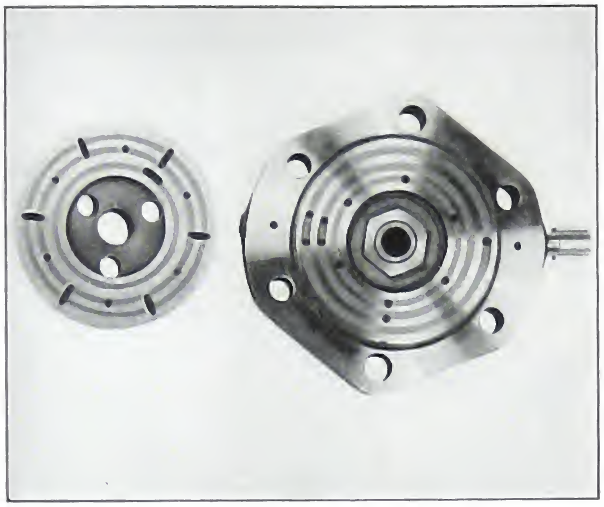


Fig. 5-23. Worn distributor disc and cover

7. The distributor disc and cover will show signs of wear, as shown in Figure 5-23, after a normal period of service. These discs and covers may be exchanged for reground sets from the factory.

However, if the disc and cover have been badly scored and show definite heat cracks between the transfer slots, they can not be reground successfully and are not subject to allowance on a reground set. If the depth of the transfer slot is less than 7/64", or if the relief has been ground from the disc, it cannot be reground.

GEAR PUMPS—Disassembly: 1. For purposes of identification, the inner gear pump that supplies fuel from the fuel tank to the float chamber will be designated as the Number 1 gear pump.

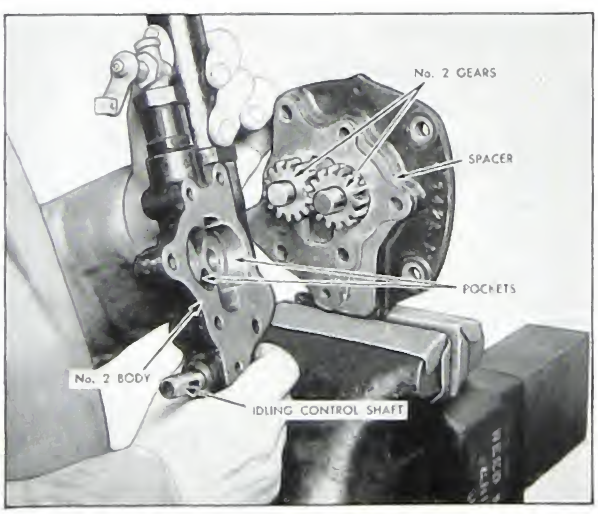


Fig. 5-24. Number 2 gears and body

The outer, or Number 2 gear pump, supplies fuel from the float chamber through the distributor to the metering pump.

2. Remove the three bolts which hold the two pump bodies together.

3. Remove the idling control lever pin. After taking out the cotter pin and washer on the end of the idling control shaft, check the shaft to see that it is tight. On all fuel pumps previous to No. 28747, this hole was connected to the suction side of the Number 1 gear pump. A loose idling shaft on these early pumps will allow air to be drawn into the fuel channels and result in scored gear

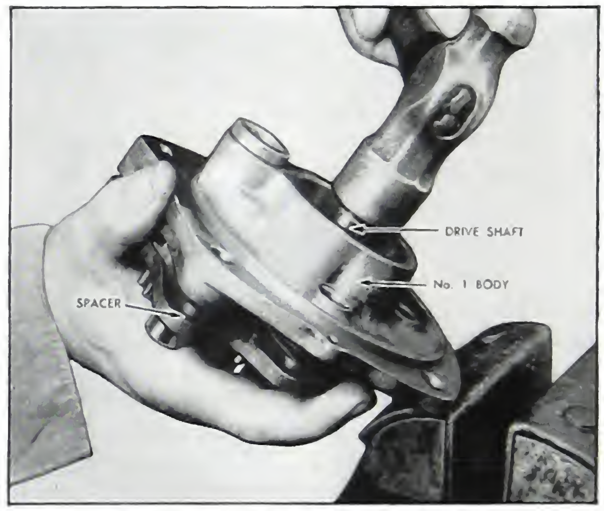


Fig. 5-25. Removing gears from Number 1 body

pumps, discs and covers and generally inaccurate metering of the fuel.

4. Drive the bolts from the bodies with a bronze punch. The Number 2 body should slip off, leaving the gears on the shafts with the spacer plate and Number 1 body. Fig. 5-24.

5. Remove the fillister head screw from the front of the Number 1 body.

6. Tap the gear pump drive shaft from Number 1 gear body. This releases the gear, shaft and spacer plate from the Number 1 body. (Fig. 5-25).

7. Pull or lift the idler shaft and gears from the spacer plate, being careful not to lose the oil seal and washer between the spacer plate and the Number 2 pump gear. (Fig. 5-26).

8. Place the Number 1 pump drive gear in a vise fitted with copper jaws, gripping the gear by the teeth and tightening the vise only enough to hold. Tap lightly on the slotted end of the

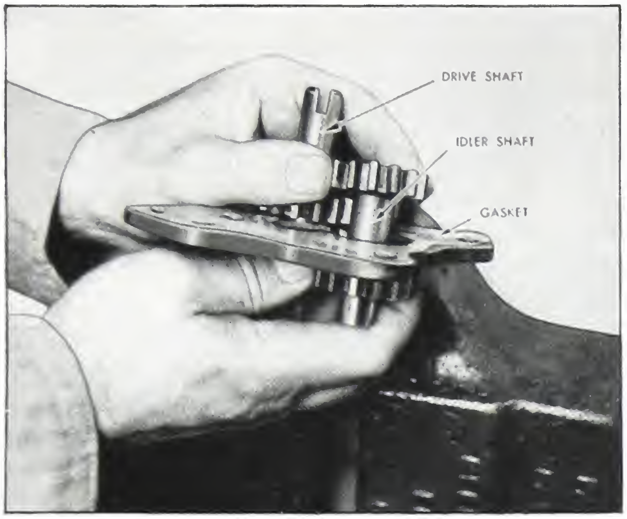


Fig. 5-26. Removing idler shaft and gears from spacer plate

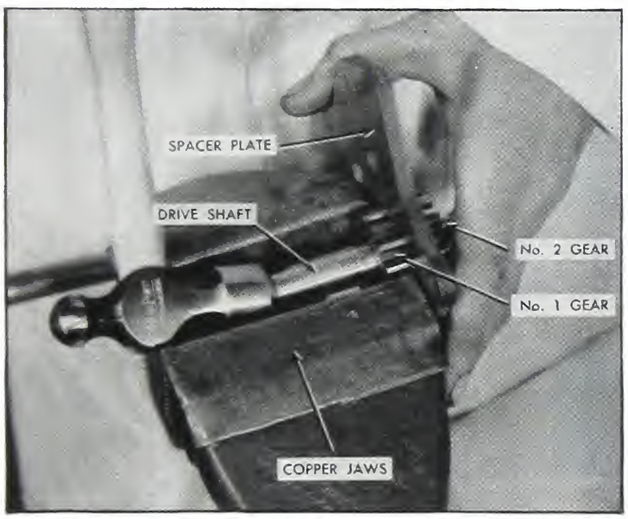


Fig. 5-27. Removing Number 1 pump gear from shaft

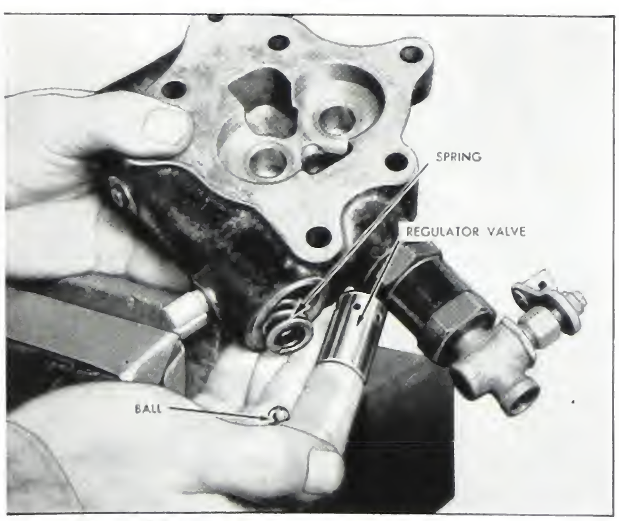


Fig. 5-28. Pressure regulator valve, spring and ball check

shaft to drive it out of the gear. Pull the Woodruff key from the shaft. Fig. 5-27.

CAUTION: ANY OTHER METHOD OF REMOVING THIS GEAR WILL CAUSE THE SMALL WOODRUFF KEY TO BE DRIVEN THROUGH THE SPACER PLATE, MAKING THE SPACER PLATE UNFIT FOR FURTHER USE.

9. Slide the gear and shaft out of the spacer plate being careful not to damage the washer between the gear and spacer plate.

10. Press the gear away from the lock ring to remove it from the gear pump drive shaft. Remove the Woodruff key and lock ring from the shaft.

11. Press the Number 2 idling gear from its shaft.

12. Unscrew the pressure chamber and remove the chamber and gasket.

13. Remove the pressure regulator valve and take out the spring and check ball. It can generally be removed by inserting a finger and pulling it out, but if it should be stuck, a tool with a projection to catch in the ports will be necessary to pull it. ST-175 is such a tool. (Fig. 5-29).

14. The pressure regulator valve sleeve is a very close fit in the gear pump body. Unless it is badly scored or worn excessively it will not be necessary to remove it. However, it may be removed easily with a puller, ST-170, that is made to catch under the lower part of the sleeve.

15. Remove the fuel supply check valve housing by screwing out the check valve seat. (Fig. 5-31).

16. The fuel pump check valve, below the fuel pump screen, can be removed by inserting a finger and pulling it out. (Fig. 5-33).

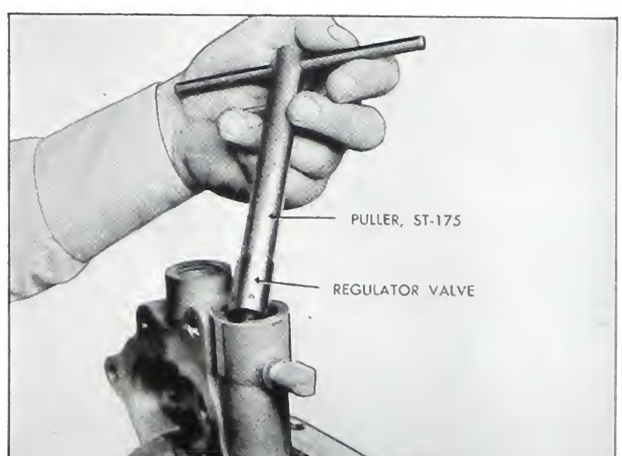


Fig. 5-29. Puller for regulator valve, ST-175

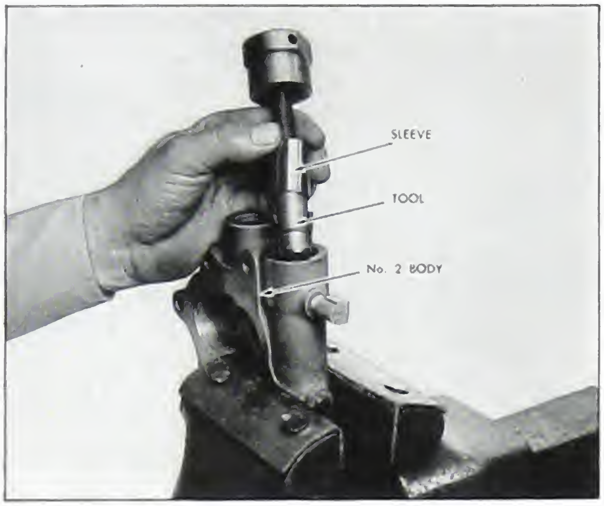


Fig. 5-30. Pulling pressure regulator valve sleeve with ST-170

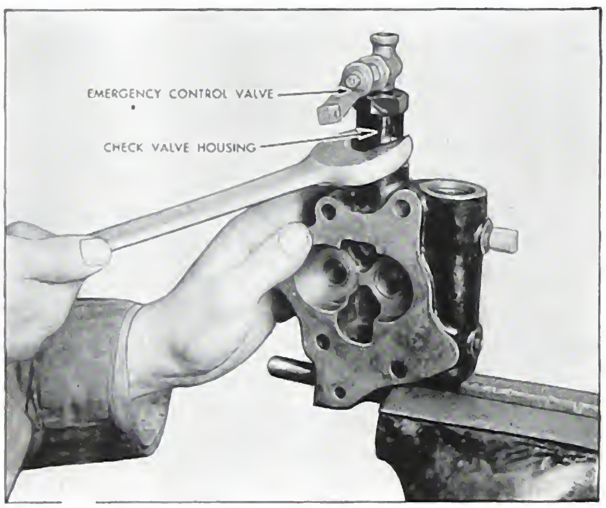


Fig. 5-31. Removing check valve housing

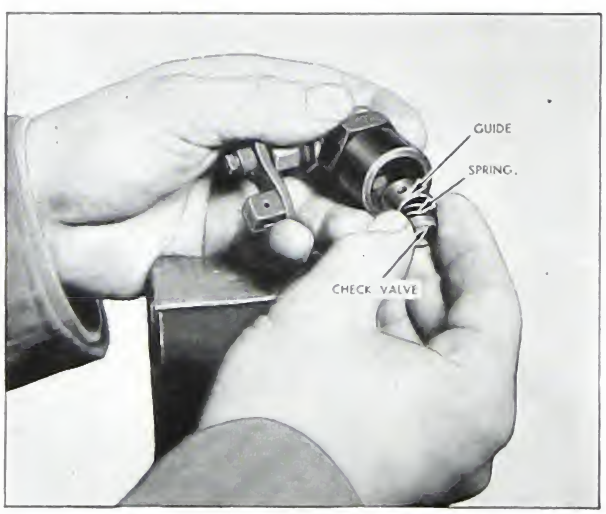


Fig. 5-32. Check valve, spring and guide

17. Thoroughly clean all disassembled parts in solvent and dry with clean, compressed air.

Inspection: 1. Check the fit of the pressure regulator valve in its sleeve. The pressure regulator valve must fit closely but work freely in its sleeve. If necessary, it may be cleaned with a very fine grade of crocus cloth. If it shows wear, or is pitted or scored, both sleeve and valve must be replaced new.

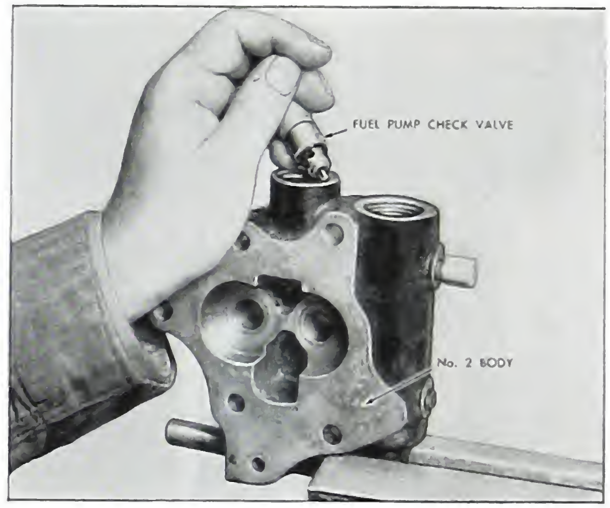


Fig. 5-33. Removing fuel pump check valve

2. Check both No. 1 and No. 2 gear pockets with a new gear and a feeler gauge. If a .005 feeler will enter between the side of the pocket and the gear, replace the body. New pockets are 1.6028/1.6035.

3. The bottom of the gear pockets must be smooth and uniform in depth—clear to the edge. Use a dial indicator depth gauge to measure gear pocket depth, Fig. 5-35. When the gears are

Fig. 5-34. Checking gear pocket size

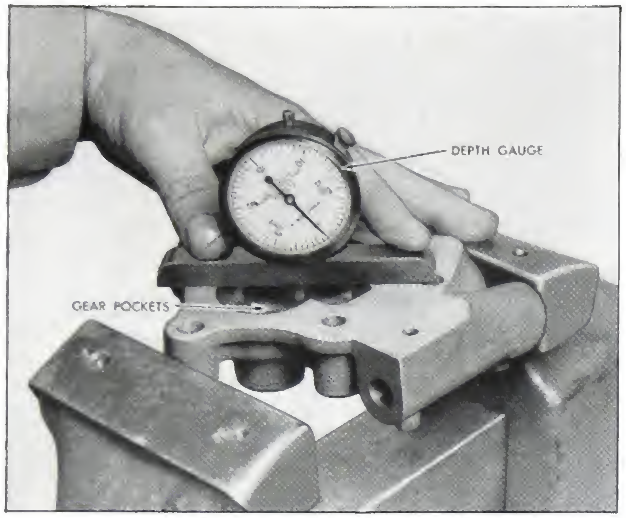


Fig. 5-35. Checking gear pockets

assembled in their pockets, they must be flush with the face of the body.

4. A straight edge can be used in an emergency, but if used, it will be necessary to check with Prussian blue to make sure that the gears are in contact with the entire pocket and not being held up by high points near the edge. Fig. 5-36.

5. If the bottom of the pockets are scored or worn unevenly they must be refaced and the body lapped.

6. Inspect the milled end of the drive shaft where it engages the fuel pump main shaft, and if it shows any wear, replace it with a new one. Both the gear pump drive shaft and drive pin in the fuel pump mainshaft must be in good condition. Fig. 5-37.

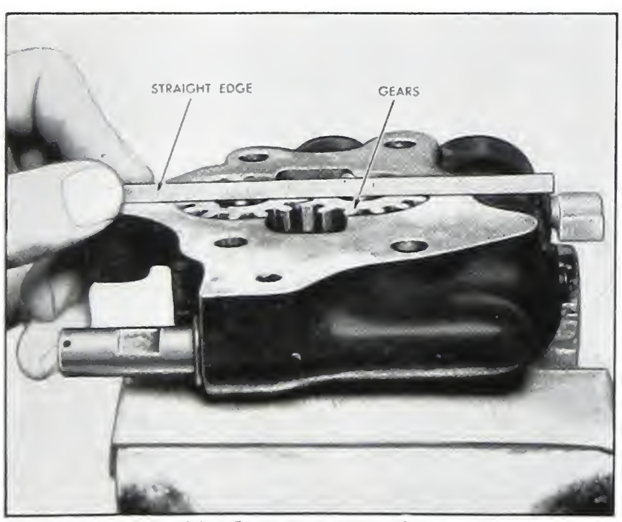


Fig. 5-36. Checking gear pockets—alternate method

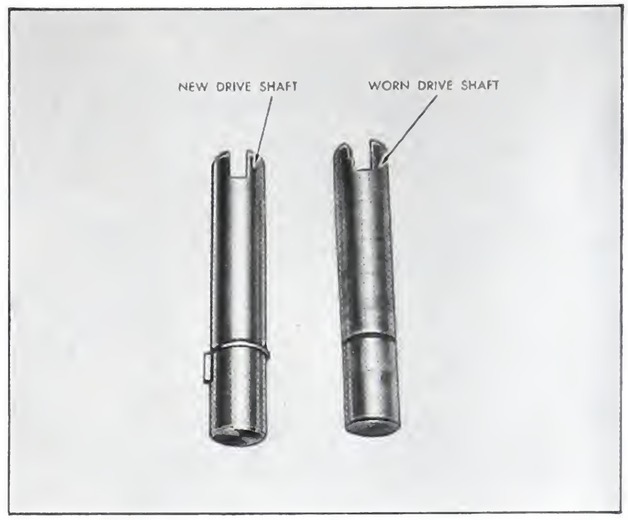


Fig. 5-37. New and worn gear pump drive shafts

7. Check both No. 1 and No. 2 gear bodies to see that they have the 1/16″ drilled holes to lubricate the drive and driven shafts. Mark for drilling if the bodies are "old style" and do not have this provision. See Fig. 5-84.

8. Inspect the cam rocker lever bushing in the No. 1 gear pump body for out-of-round and wear. Worn limit is .6265.

9. The fuel gear pump spacer plate faces must be parallel within .0005 between any two points 3 inches apart and smooth finish. The 13/16 counterbore for oil holes must be 1/64 deep. Spacer plates can be repaired by lapping or surface grinding and by restoring bore depth.

10. After assembly the rebuilt gear pump should pass the following tests:

a. Gear pump should turn by finger grip on drive shaft.
b. Fuel pressure at idling speed (500 rpm) should be in excess of 65 psi.
c. Pump should not get hot (more than 120° F.) during 20 minute test.
d. Maximum pressure, vacuum, shut-off, etc., should be as specified in "Testing and Calibrating" section, Page 5-101.

FLOAT CHAMBER: 1. Remove the two capscrews holding the top plate to the float chamber and remove the plate and float assembly from the float chamber.

2. Remove the nut and washer from the float bearing pin and remove the pin. This allows the float, float stop and float valve to come free.

3. With a small wrench, remove the float valve

seat from the top plate. Be careful not to lose the gasket under the seat. Fig. 5-39.

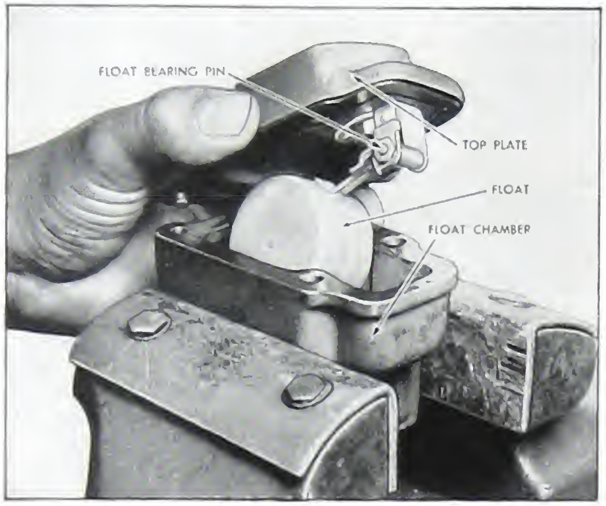


Fig. 5-38. Top plate and float assembly

4. Check the float valve and seat with Prussian blue to see that they will seal properly.

5. Check the float for cracks or leaks.

6. Check the position of the float in valve shut off position during assembly of float chamber. When valve is shut off the top of the float should have 1/16 clearance as shown in Fig. 5-101.

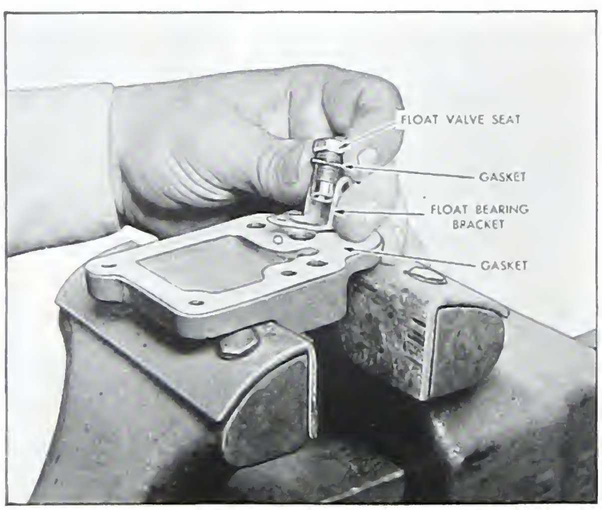


Fig. 5-39. Float valve seat

FUEL PUMP HOUSING: 1. Remove the vertical lever spring from the plunger lever pin.

2. Drive the pin from the plunger lever, making sure not to lose any of the 56 needle bearings in which it is mounted. If the plunger lever is placed on a 1½" socket during the operation, the socket will catch the needle bearings. Fig. 5-40.

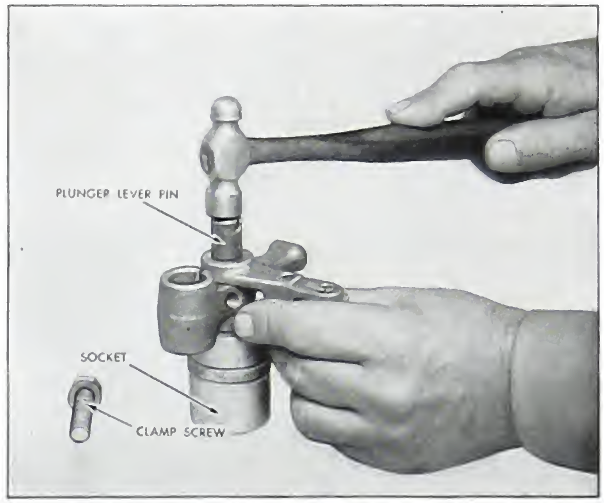


Fig. 5-40. Plunger lever pin

3. Use a small punch and a socket to drive the pin from the vertical lever roller, making sure not to lose any of the 22 needle bearings.

CAUTION: KEEP THESE LONG NEEDLE BEARINGS SEPARATE FROM THE 56 REMOVED FROM THE PLUNGER LEVER PIN.

4. Inspect the vertical lever, pin roller and roller pin. If they are worn, replace them. If parts are worn or pitted, poor governor action will result. Replace needle bearings if lever pin and roller is worn as shown in Fig. 5-42.

5. Mount the cam rocker lever in a vise and drive out the roller pin with a small punch as shown in Fig. 5-43.

6. Use a small brass rod to remove the roller pin as shown in Figure 5-44.

7. Inspect the cam rocker lever roller and pin

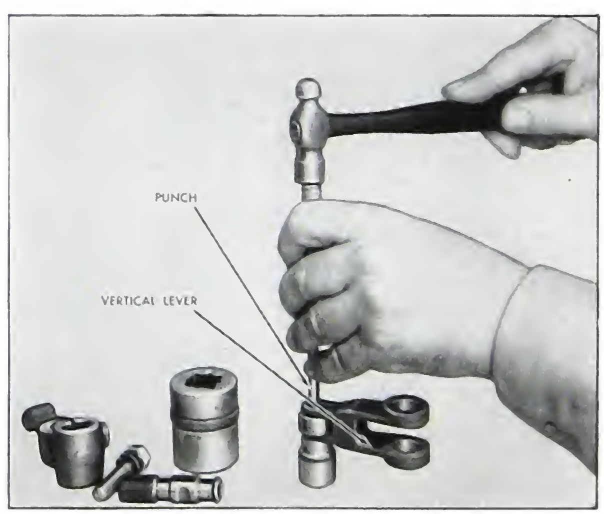


Fig. 5-41. Vertical lever roller

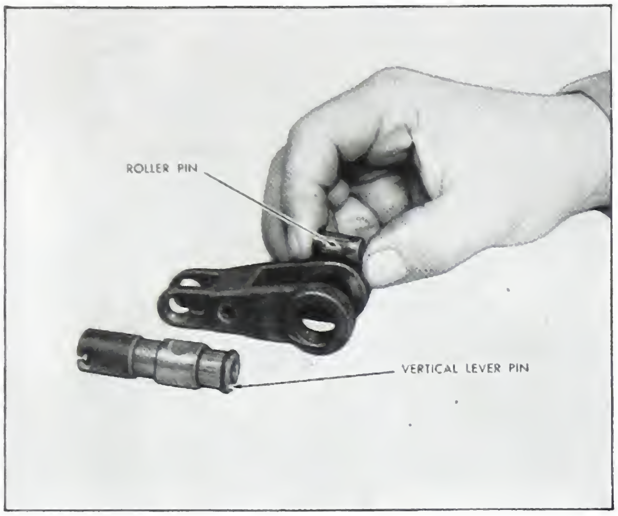


Fig. 5-42. Worn pins

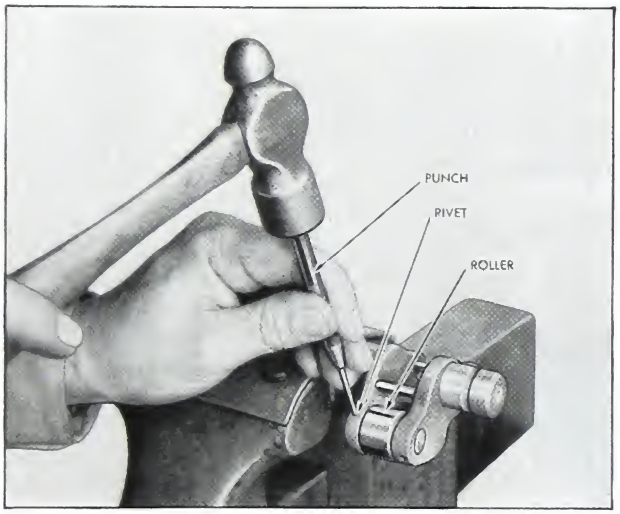


Fig. 5-43. Removing rivet from roller pin

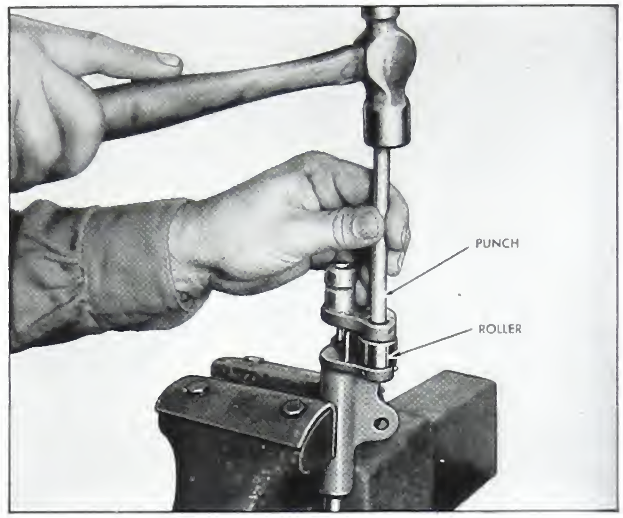


Fig. 5-44. Removing roller pin

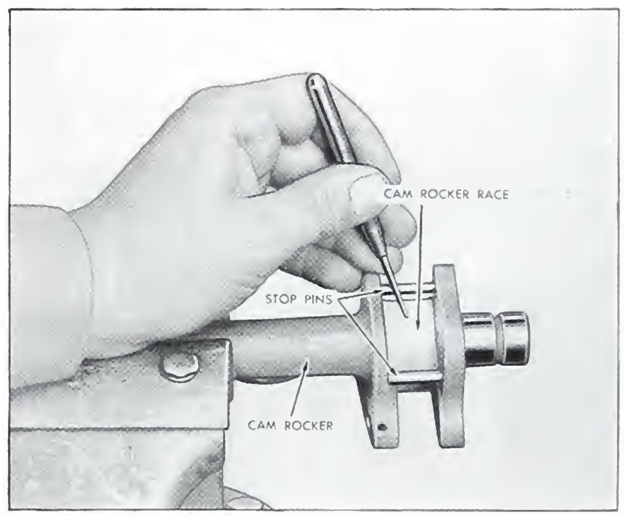


Fig. 5-45. Cam rocker race

for wear. Mark for replacement if any visible wear can be detected on either part. Uneven wear of the roller can be detected easily by light reflection as the roller is turned.

8. Inspect the cam rocker lever for wear on the ground radius where the roller operates. If the lever is rough or grooved, replace it to prevent bad governor action. Fig. 5-45.

9. Late style cam rocker levers are drilled for lubrication at the gear pump end. Old style lever can not be drilled but the No. 1 gear housing and bushing should be drilled as shown in Fig. 5-46, if the undrilled rocker lever is to be used.

10. Drive out the rivet from the fuel control lever that locates it in place on the serrated shaft. Loosen the capscrew and tap the fuel control lever from the eccentric shaft. Fig. 5-47).

11. Remove the cotter pin from the collar with a pair of diagonal cutters and remove the collar while working from inside the main housing. Remove the governor lever and linkage from the eccentric lever and from the main housing.

12. Inspect the ball joints in the vertical lever link and the governor lever link for wear or rough action. The springs must hold the links without any lost motion but the balls must turn smoothly to prevent bad governor action. Fig. 5-48.

13. Center-to-center lengths of ball joints in links are as follows:

Mechanical governor link, 4829-4............4″
Hydraulic governor link, 62309..............1⅝″
Vertical lever link, 9123-7.........................1⅜″

To check these lengths, make a simple check-

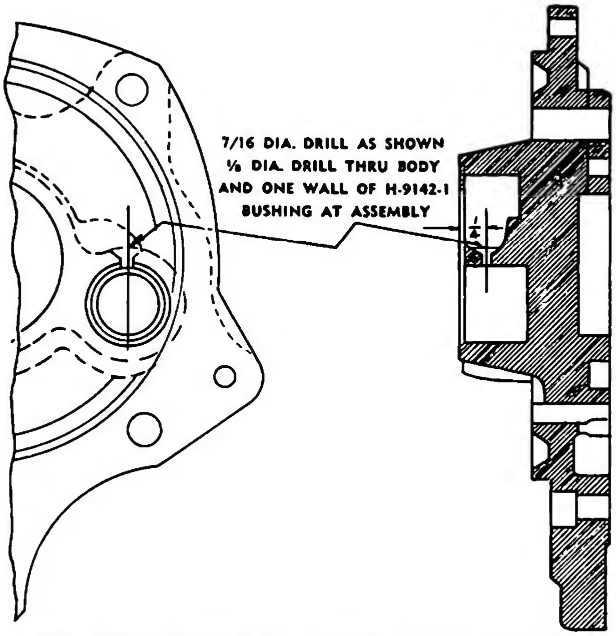


Fig. 5-46. Drilling to provide cam rocker lever lubrication

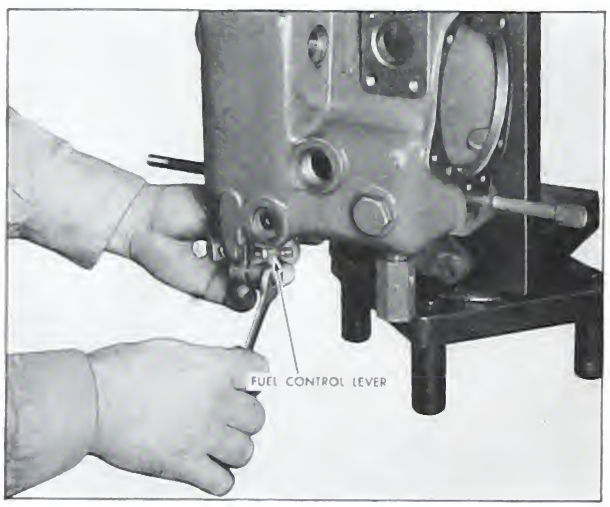


Fig. 5-47. Fuel control lever

ing fixture by drilling ¼" holes to receive the screws, in 1" steel blocks.

14. If link dimensions are wrong, correct them.

Hydraulic: 15. Inspect the governor control shaft for wear. Discard if worn beyond .4975. For this and all other small shafts and bushings test the fit of the shaft and bushing in addition to gauging individual parts. Fig. 5-49.

Mechanical: 16. The large and small ends of the hand control eccentric must not be worn smaller than .561 and .499 respectively. Basic new dimensions are .5625 and .500.

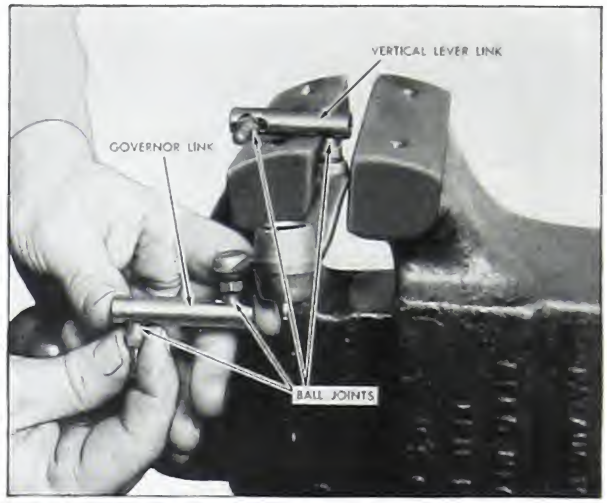


Fig. 5-48. Testing ball joints

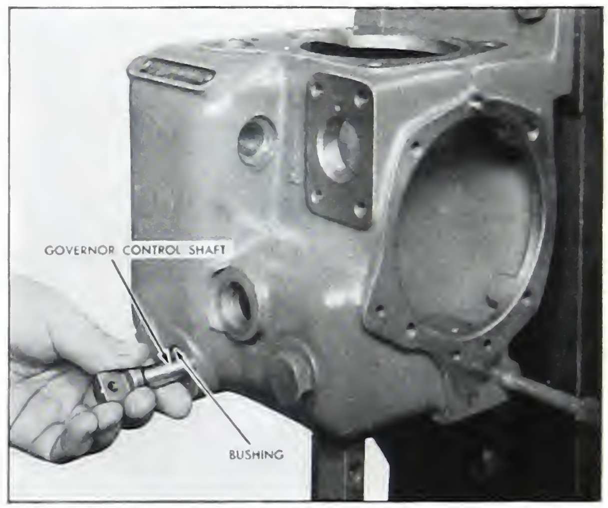


Fig. 5-49. Testing for wear of shaft bushing

17. Minimum and maximum new dimensions and maximum worn dimensions for bushings in the fuel pump housing are shown in the following table. Mark bushings for replacement as needed.

BUSHINGS IN FUEL PUMP HOUSING

Part No.	Name of bushing	Min. new	Max. new	Worn replacement limit
9124-2S	Cam rk'r lever bush.	.812	.8125	.8135
62351	Control shaft bush. (Hydraulic)	.4995	.5005	.5015
60466-S	Gov. control rod bush. (Mechanical)	.6262	.6272	.6285
9144-S	Plunger lever shaft bushing	.749	.7495	.7505
9125-S	Plunger lever shaft bushing	.749	.7495	.7505

18. Hand control eccentric and governor lever must be fitted with needle bearings. See instructions in rebuilding section.

GOVERNOR AND MAINSHAFT—Mechanical: 1. Remove the governor weights by first tapping weight pins far enough to one side to permit grinding or filing off riveted heads. Drive the pins out, taking care not to damage small ball bearings in weights.

2. Pull or press the governor yoke from the governor shaft, being very careful not to damage the yoke. (Fig. 5-50).

3. Remove the key from the drive end of the governor shaft and take off the spring assembly.

4. To remove the governor sleeve collar and thrust washer from spring assembly, first remove the snap ring. The thrust washer is prevented from turning by the pin in the collar.

5. Remove the governor spring by compressing the spring and taking out the split lock rings in the governor sleeve.

6. Inspect the ball bearings on the mainshafts after they are washed in mineral spirits and dried with compressed air. Ball bearings should be replaced if rough or if races are worn enough to detect shake.

7. Inspect the fuel pump cam. The 4 cylinder Model H fuel pumps use cam No. 4822. No. 4771-1 is used on 6 cylinder H, HS and NH models. For identification purposes, the No. 4822 and No. 4771-1 cams have .0414 lift while the lift of No. 41812 is .0612. Actual lift of cam lobes must be compared after assembly in fuel pump with ST-104 as detailed in "ASSEMBLY AND ADJUSTMENTS", page 5-54. Cam must be discarded if it shows uneven wear or "ripples". Mark cam for replacement if the gear teeth are scuffed or measurably worn. If cam is replaced, the bevelled distributor gear should also be replaced since new and old gears should never be matched.

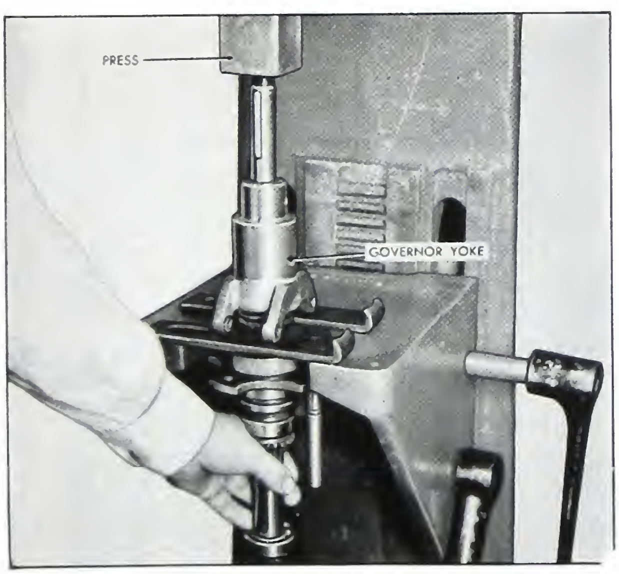


Fig. 5-50. Removing governor yoke

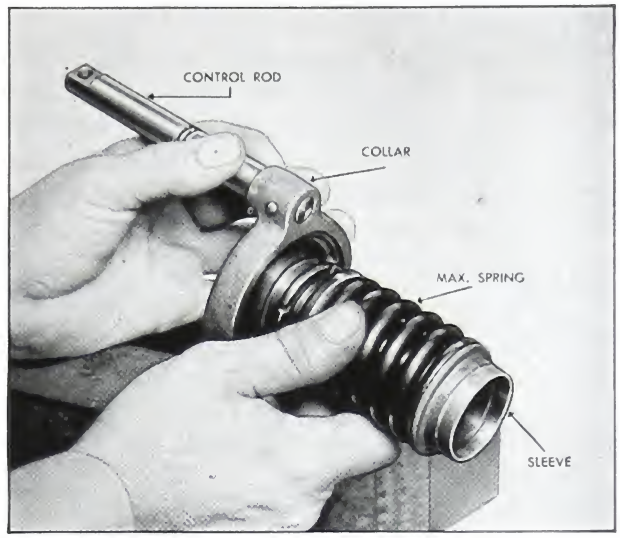


Fig. 5-51. Control rod and collar assembled to yoke sleeve

8. Maximum speed spring and weight combinations are shown in current parts book. Consult "Spring Data" tabulation for weights required to compress maximum speed spring and idling spring. Actual governed speed must be proven on the fuel pump test stand.

As a general rule governed speed is increased 3 rpm for each higher number stamped on governor weights, or for each pound difference required to compress maximum speed springs. This is true for 1800 rpm range. At 1200 rpm these values change to 15 rpm for each 8 pounds difference or 8 points on governor weights.

Spacers back of spring are also used to help regulate governed speed.

9. The center-to-center dimension of governor control rod with mainshaft must be 1.7662/1.7692 to insure free action in assembly. Assembly can be checked with main housing and shaft assembly. Collar and rod must be rigidly assembled.

CAUTION: GOVERNOR CONTROL ROD AND COLLAR MUST NOT BE DISASSEMBLED EXCEPT FOR NEW REPLACEMENT.

10. The governor control rod and collar should be replaced as an assembly if the rod is smaller

than .622 or if the rod is loose in the collar.

11. Inspect the working radius on the governor weights for wear. If flattened or worn replace, using new weights bearing same number as was stamped on worn weights. This assures approximately same governed speed. Inspect the small ball bearings in the weights. If pitted or worn, replace with new bearings. It is advisable when replacing either weights or spring to replace both as a matched weight and spring combination.

12. Inspect the engaging pin for the gear pump drive. If the pin shows any wear, mark it for replacement.

13. The governor yoke tube, 9104-5, must be replaced new if it is unevenly worn on the outer surface so that it might cause erratic action of the yoke sleeve. The collar end of the tube must have the four lubricating holes drilled as explained in REBUILDING section. The tube does not often need replacement because of normal wear. Free action of the yoke sleeve over the tube is essential to proper governor action.

14. The governor yoke sleeve, 9103-6, must fit and be held for a close running fit in the governor control sleeve collar. Make sure before scrapping this part that any looseness in the collar cannot be corrected by the use of a new governor thrust ring and snap ring.

The second point of greatest wear on the yoke sleeve is at the machined slots that hold the governor weights. If all four slots are worn, replace the sleeve. If only two are worn, use the other unworn slots.

15. Gauge the steel bushing on the end of the governor yoke. If it is worn smaller than 1.622 the bushing and the yoke should be replaced as a BM-28 assembly. Also inspect the governor weight pin bushings. If they are worn out-of-round they must be replaced. (BM-28 also includes these four bushings.)

16. Gauge the governor housing bushing, No. 9114-2S. The worn replacement limit is 1.627. Newly installed and reamed bushing should gauge 1.625/1.626 and the reaming must be done in a fixture that will insure alignment.

17. Governor weights must be matched according to stamped numbers. The radius that works on the governor yoke sleeve must not be badly worn or it will interfere with governor action.

GOVERNOR DRIVE HOUSING AND MAIN-SHAFT—Hydraulic: 1. Inspect governor drive gear, ball bearings, oil seal, cam and distributor drive gear on the main shaft. To remove any of these parts proceed as follows:

2. Place the main shaft assembly in an arbor press, with the drive gear end of the shaft to the top and with the governor drive gear resting on two copper parallels. Press the shaft from the governor drive gear.

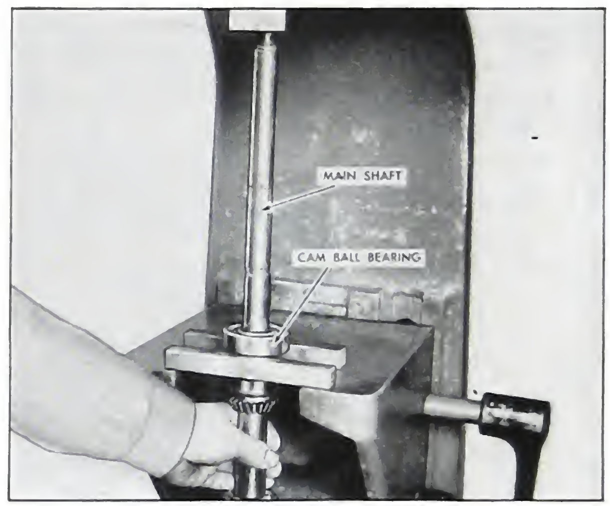


Fig. 5-52. Removing cam ball bearing

3. Hold the main shaft in a vise with copper jaws so the keyways on the shaft are to the top. Remove the keys with side cutters or with a punch.

4. Slip the bearing shield from the shaft.

5. Pull the spacer from the shaft.

6. Remove the lock ring and press the cam ball bearing from the shaft. (Fig. 5-52).

7. Place the main shaft in an arbor press with the distributor drive gear teeth resting on copper parallels or a piece of hard wood. Press the cam from the main shaft off the drive gear end of the shaft. Fig. 5-53.

8. Inspect the ball bearing on the gear pump end of the main shaft for wear or "shake" and replace if necessary.

9. Inspect the gear pump drive pin in the fuel pump main shaft. If it is worn, mark for replacement.

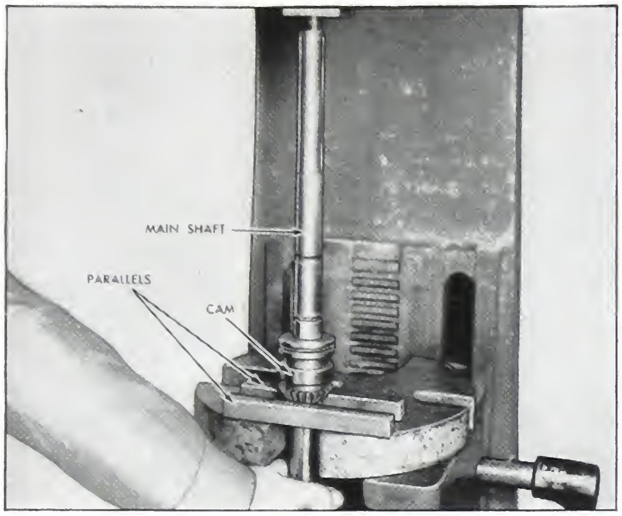


Fig. 5-53. Cam and distributor drive gear

10. Inspect the large ball bearing for wear and, if worn, replace with a new one.

11. Remove the ball bearing from the fuel pump drive gear, if worn, by prying with two opposing bars against the gear and bearing while the gear is held in a copper jawed vise.

GOVERNOR DRIVE UNIT—Hydraulic: 1. Inspect the roller bearings, pinion gear and splined shaft of the hydraulic governor drive unit for wear. If it is necessary to replace any of these parts disassemble as follows:

2. Put the splined collar on the splined shaft to avoid damage to the shaft and hold in a vise between copper jaws.

3. Relieve the lock plate and remove the locknut and washer.

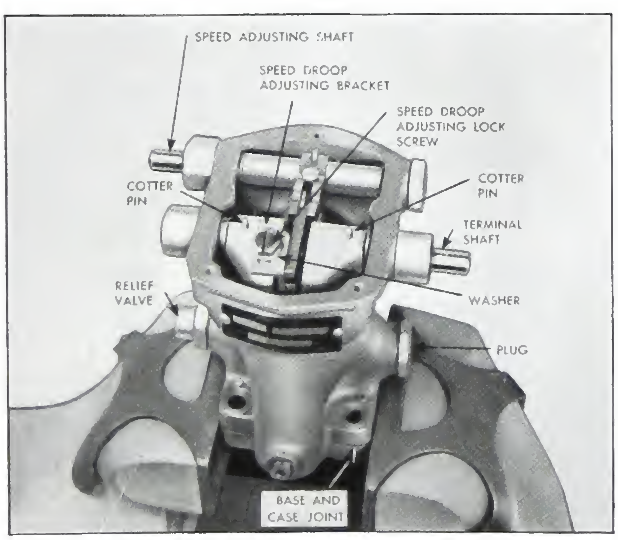


Fig. 5-54. Top cover removed

4. Press the spindle shaft from the gear and spacer, with the coupling end down on the plate. Remove the Woodruff key.

5. Use a bronze punch to press out the shaft.

6. Press the ball bearing from the pinion gear.

7. Press the second ball bearing from the spacer.

WOODWARD SG GOVERNOR: The same rules as to cleanliness and facilities apply when working on the hydraulic governor as on the rest of the fuel pump. The usual hand tools are required and a few special tools are desirable if subassemblies are to be disassembled.

Disassembly: 1. Clamp governor lightly in vise below case and base joint. Fig. 5-54.

2. Remove three screws and take off top cover.

3. Remove speed droop adjusting screw, washer and bracket.

4. Pry up two cotter pins with side cutters and remove.

5. Pull out terminal shaft.

6. Insert rod in opening and drive out opposite shaft. Fig. 5-55.

7. Remove terminal lever from governor.

8. Unscrew speed adjusting sleeve and spacer cap. Remove from governor.

9. Remove pilot valve, pilot valve bearing, and speed adjusting shaft assemblies from governor as shown in Fig. 5-56.

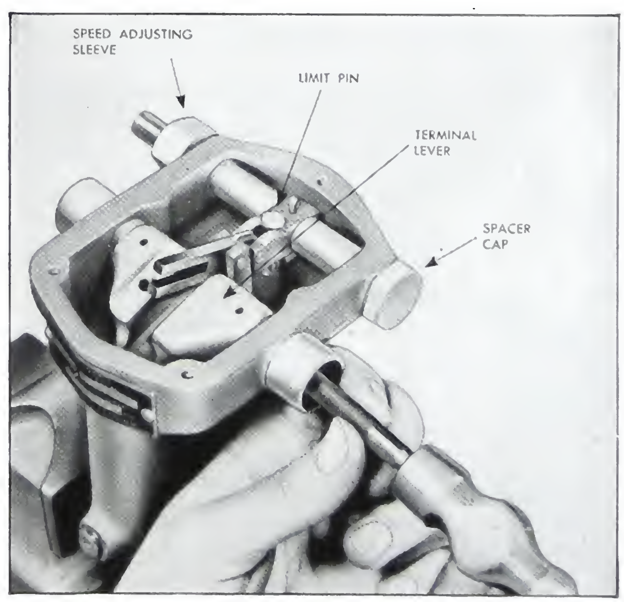


Fig. 5-55. Driving out shaft

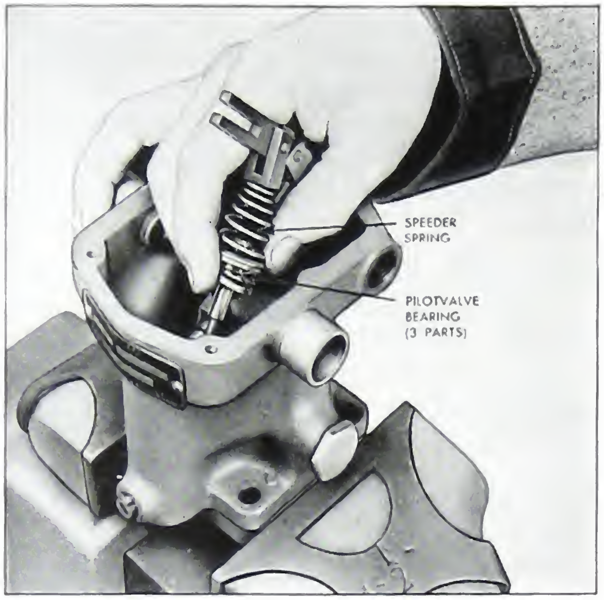


Fig. 5-56. Pilot valve bearings and speeder spring

10. Disassemble speed adjusting shaft, lever and floating lever by twisting off bent-over end of "U" shaped lockwire. Use new lockwire or two cotter pins when reassembling.

11. Unscrew relief valve assembly and plug. Remove from case. Fig. 5-54.

12. Remove governor from vise, invert, catching power piston as it falls out.

13. Strike drive shaft with plastic hammer to remove drive shaft collar. Fig. 5-57. Remove drive shaft and ballhead from case.

14. Remove base if loose enough. If tight, place 9/16" diameter brass rod in case through

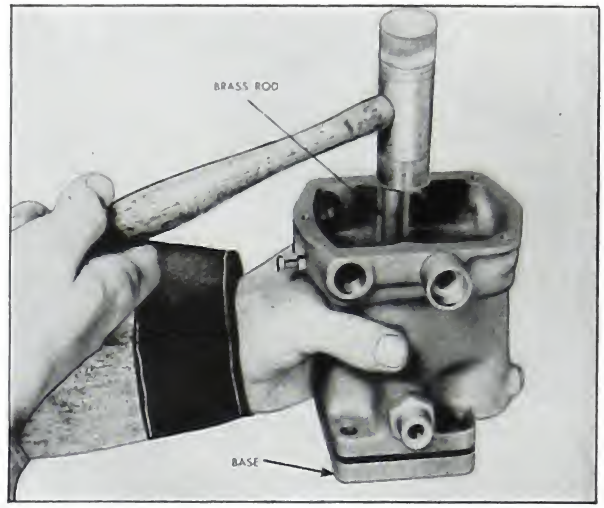


Fig. 5-58. Removing base

center hole and drive apart as shown in Fig. 5-58 or, if desired, as shown in Fig. 5-59. Hold hand under base to case joint to catch pump gears. See Fig. 5-60 for arrangement of parts.

15. Clamp idler stud in split strap clamped in vise, as shown in Fig. 5-61. Twist and pull on case to remove idler stud.

16. The terminal sleeves are pressed into the case. Insert 5/16" threaded rod through one side, screw on a nut, and drive out sleeve. See Fig. 5-62.

17. The oilite bearings in the terminal sleeves may be pressed out of the sleeves and replaced when worn. If replaced, they must be line reamed with a .375 standard line reamer.

18. Remove pilot valve bearing.

19. Insert a thin screw driver between the

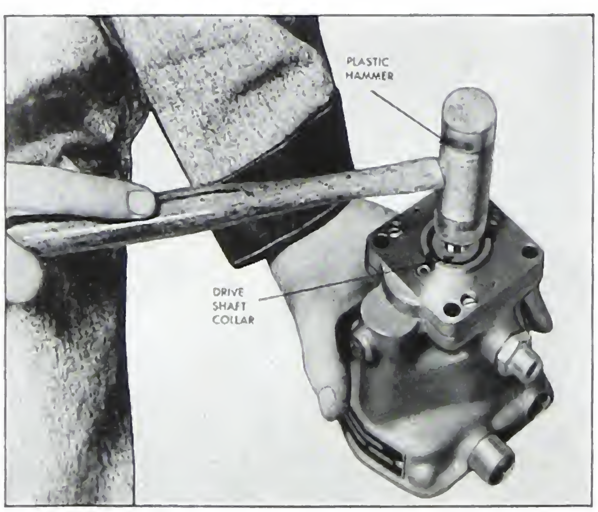


Fig. 5-57. Removing drive shaft collar

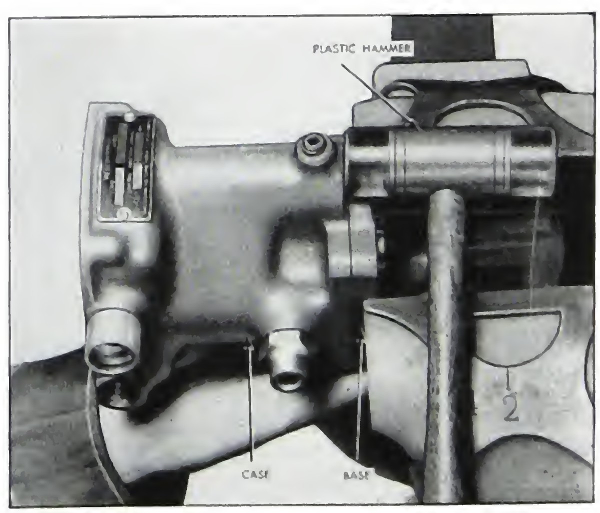


Fig. 5-59. Alternate method of removing base

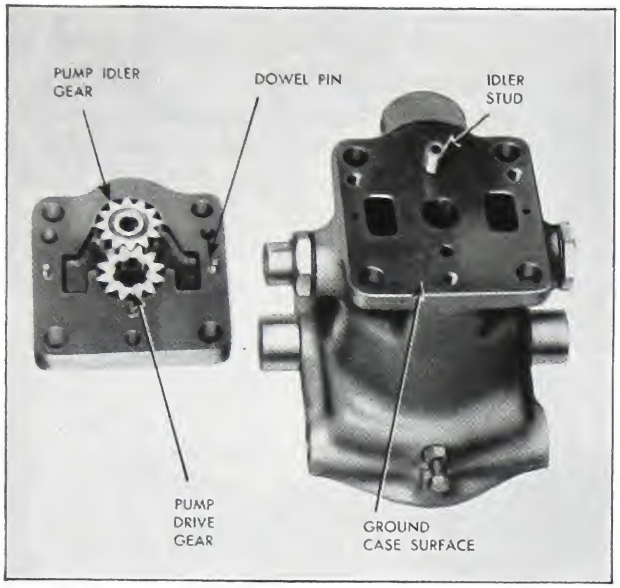


Fig. 5-60. Gears in base

spring and spring fork. Clamp the fork in a vise and drive off the spring as shown in Fig. 5-63.

20. To disassemble the relief valve: Insert long nose pliers in the end to depress the plunger as shown in Fig. 5-64. Grip the pin and slide the pin half way out. Depress the plunger and pull out the pin with fingers.

CLEANING: Clean all disassembled parts in mineral spirits and dry with compressed air.

INSPECTION: 1. Inspect the pilot valve plunger for fit in the bushing. Excessive wear on either of

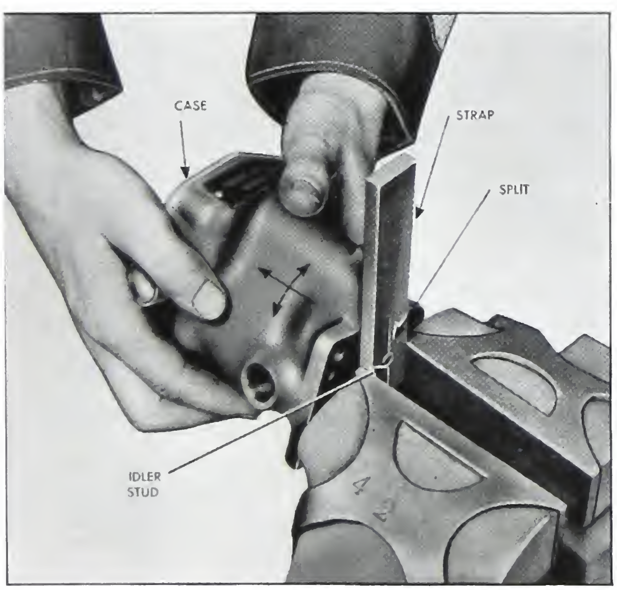


Fig. 5-61. Pulling idler stud

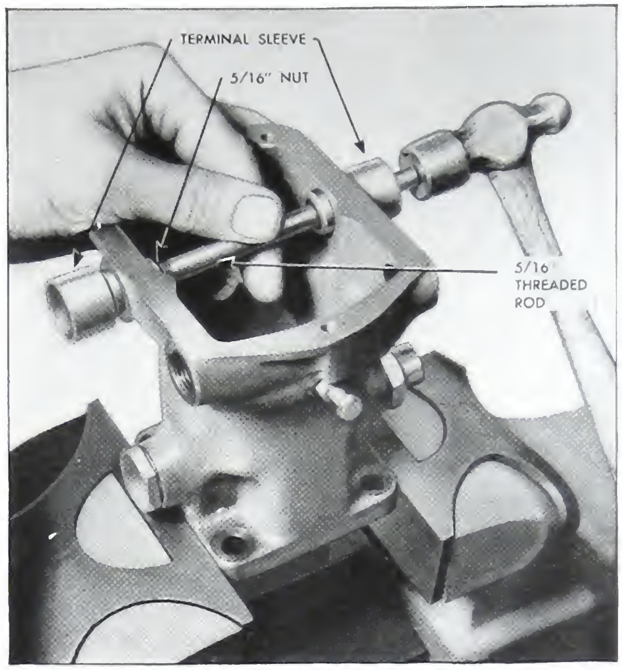


Fig. 5-62. Driving out sleeve

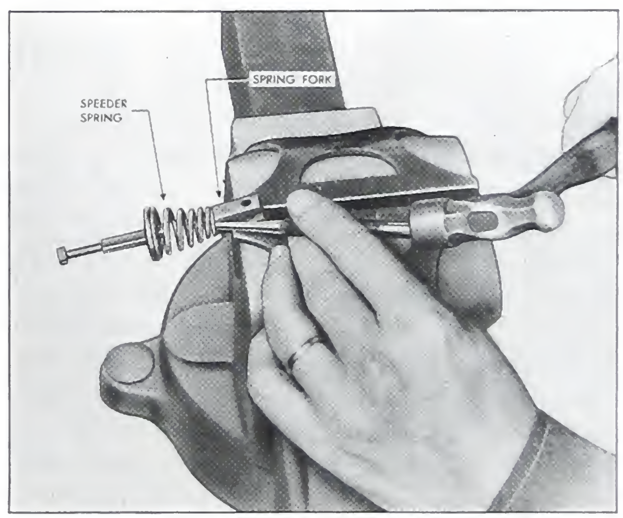


Fig. 5-63. Driving off speeder spring

these parts would interfere with the valve action. The land of the pilot valve must have sharp edges for satisfactory operation. Replace new if worn.

2. Inspect the bottom flat surface of the governor case. Grooves or scores or scratches must be removed by surface grinding or lapping on a lapping plate.

3. If the ground flat surface of the governor base is warped, scored or grooved it must be surface ground or lapped. If the gear pockets are

Fig. 5-64. Disassembly of relief valve

scored the base must be replaced with a new one.

4. The power piston must work freely in the body but excessive clearance will permit leaking by the piston and loss of work capacity.
5. Replace other visibly worn parts as needed.

REBUILDING

OVERSPEED STOP—*Shaft Bushing:* Replace overspeed stop shaft bushings, No. 62371-S, as needed. Press the new bushings all the way to the shoulder and ream to .562/.563 with a spiral hand reamer long enough to reach through both bushings. Unless the bushings are pressed tight to the shoulder there will be insufficient end clearance in the assembly.

Weight: 1. Clean the weight and the bore in the shaft. Check for burrs. Replace the weight and spring and secure in place with the collect and cotter key. Test for free action.

2. If it is necessary to replace either the weight or spring, they should be secured as a combination for the particular pump speed. Weight and spring combinations are supplied to trip at about 15% overspeed. (Tripping speed can be checked while running the fuel pump on a test stand as shown in Fig. 5-175.)

Valve: 1. Lap the valve and seat with fine grade lapping compound or replace valve and body as an assembly as determined by inspection.

2. Replace the valve spring gasket and body plug to the body.

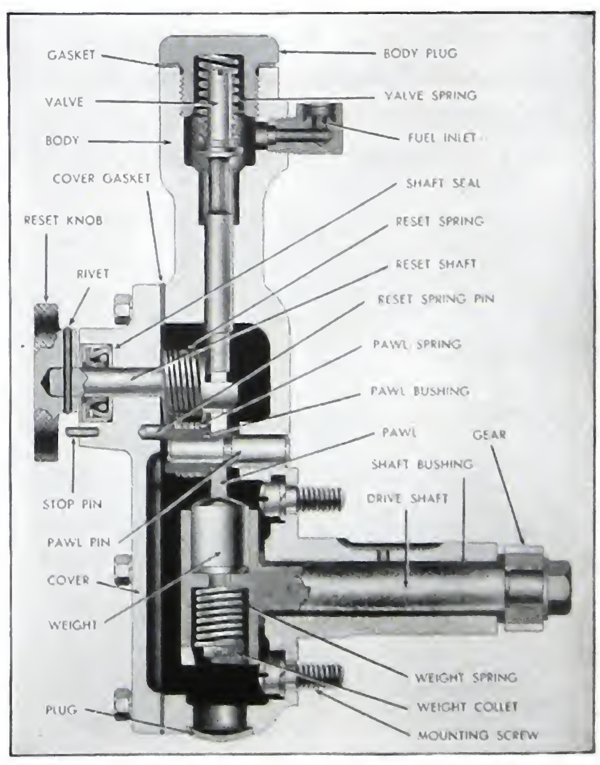


Fig. 5-65. Cross section of overspeed stop

Oil Seal: Insert a new oil seal in place with the sealing lip toward the spring.

Reset Knob: 1. If a new reset shaft is being used, it will be necessary to locate the reset knob in the proper relation to the flat surface on the reset shaft. The flat surface on the shaft must be assembled to the top and in horizontal position—and the reset knob as shown in Figure 5-65. Drill the shaft with the knob in position. Drive a groove lock pin through the shaft and knob a little below flush.

2. Assemble the reset spring to the shaft in position.

3. Complete assembly and installation as outlined on Page 5-54—after repairing other units of the fuel pump.

DISTRIBUTOR—*Priming Valve:* 1. If the priming valve seat has been damaged, reface it with seating cutter, ST-191. Remove only as much stock as necessary to obtain a true seat. Check the new seat with Prussian blue. Remove all particles with compressed air.

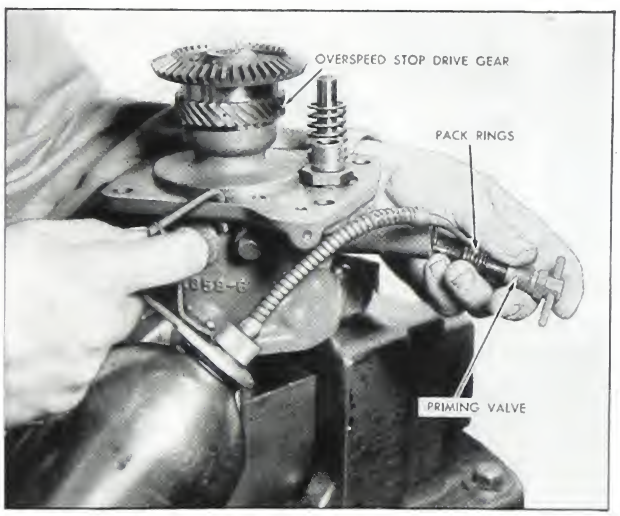


Fig. 5-66. Priming valve assembly

2. Replace the priming valve with pack rings assembled, and tighten the packing nut so the valve turns normally by finger pressure.

Lubricating Check Valve: Assemble the lubricating check valve ball and spring in the distributor housing. See Figure 5-68 for drilled lubrication passages in the main housing. Check the lubricating check valve seat for leaks and the breaking point during fuel pump test.

Shaft and Collar: If either the distributor

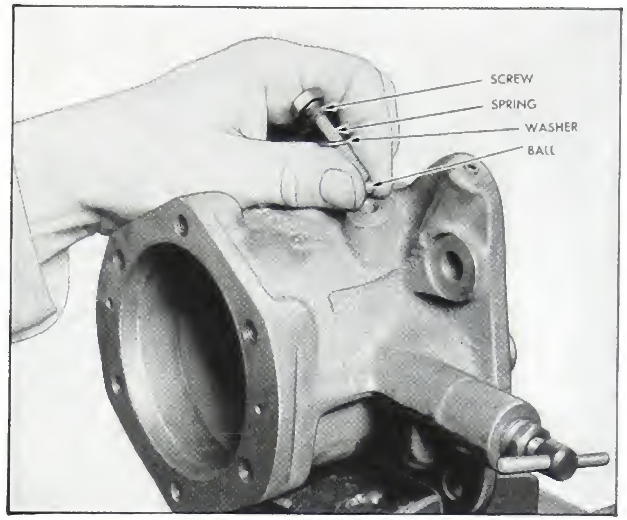


Fig. 5-67. Lubricating check valve

shaft or collar has to be replaced, both must be replaced as an assembly. This is necessary because the thrust face of the collar must be ground with the shaft in assembly to insure a good seal on the distributor shaft bearing face.

Disc Pins: 1. Replace distributor disc pins if inspection has determined that they are worn. Grasp each of the pins alternately between the jaws of a vise and drive against the top of the collar to remove. Press in new pins.

2. One pin is offset to insure proper disc timing. The position of the offset pin in relation to the timing notch on the collar varies with RH or LH fuel pump. Consult Figure 5-69, for identification.

Shaft or Thrust Bearing: 1. One of the most particular operations in the rebuilding or repairing of the fuel pump is that of replacing the thrust bearing. It must never be pressed from the housing unless inspection shows that it is worn or scored. If it is excessively worn in the shaft hole as determined by inspection, it will be necessary to press or drive it from the housing, from the bottom side. Use mandrel, ST-145.

2. A special piloted mandrel, ST-75, is essential to the replacement of the thrust bearing. Without a tool of this kind the thrust bearing would be sheared by the housing as it was being pressed into the housing and a perfect seal would be impossible. Fig. 5-71.

3. Clean the housing thoroughly and check to see that there are no burrs on the shoulders of the housing. Be very careful to press the new

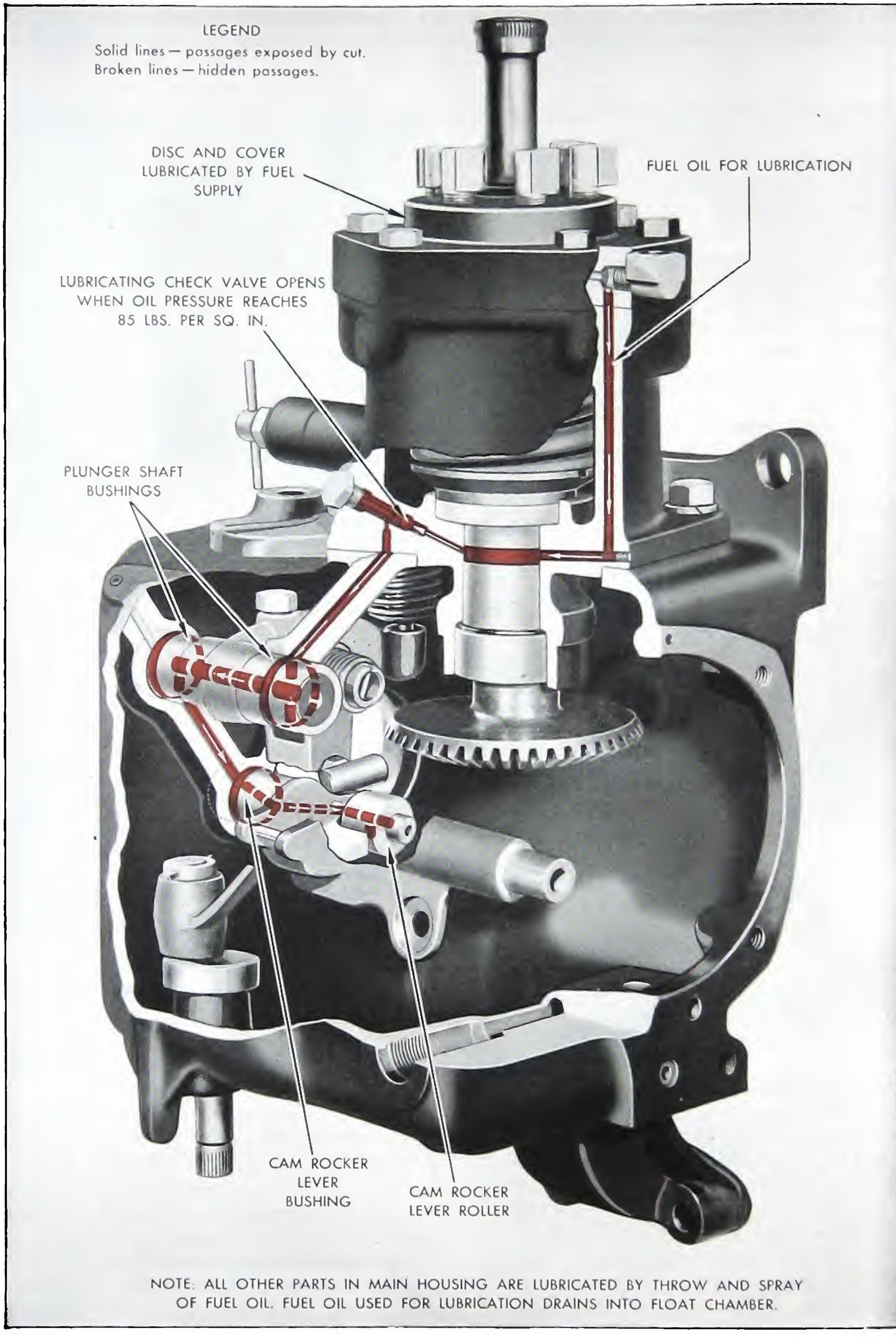


Fig. 5-68. Lubrication of fuel pump main housing parts

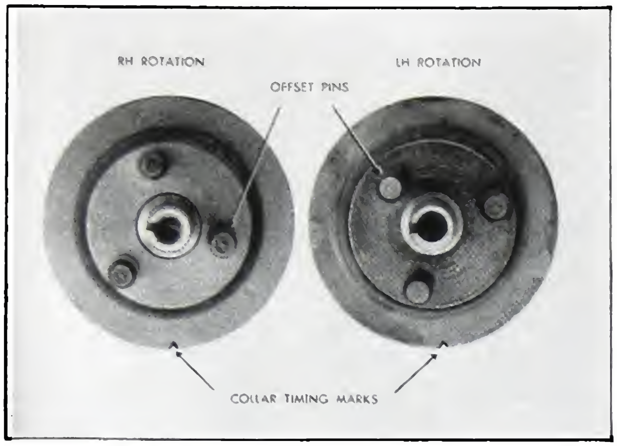


Fig. 5-69. Distributor disc pins in relation to collar timing mark

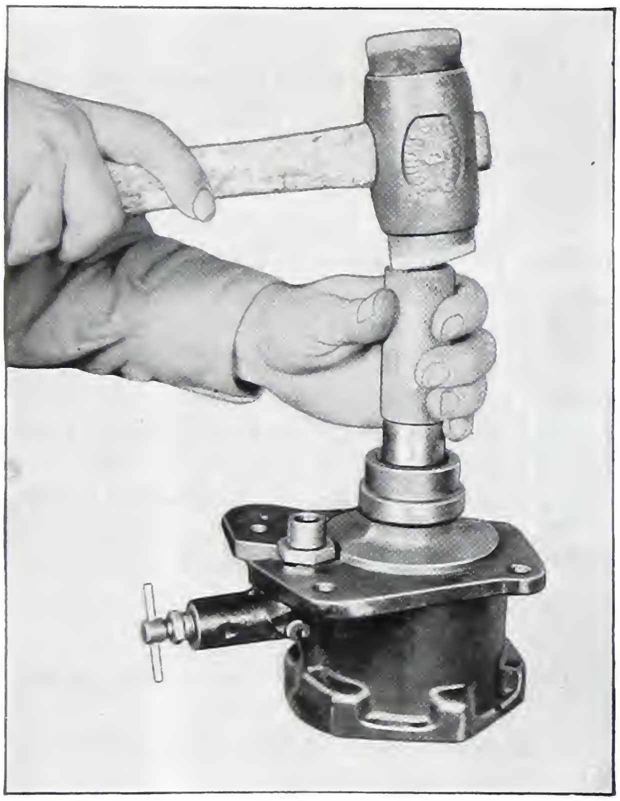


Fig 5-70. Driving out distributor thrust bearing

bearing in straight to avoid cutting.

4. Locate the special piloted reamer, ST-215, as shown in Figure 5-72 and ream the shaft hole in the distributor shaft bushing to .812/.813. Both pilots must be used to insure alignment.

5. Use a cutter of service tool, ST-183, to face the thrust bearing. Never cut away more metal than necessary to "clean up". The cutter of ST-183 has a negative rake to prevent chattering and, for that reason, it will be necessary to apply

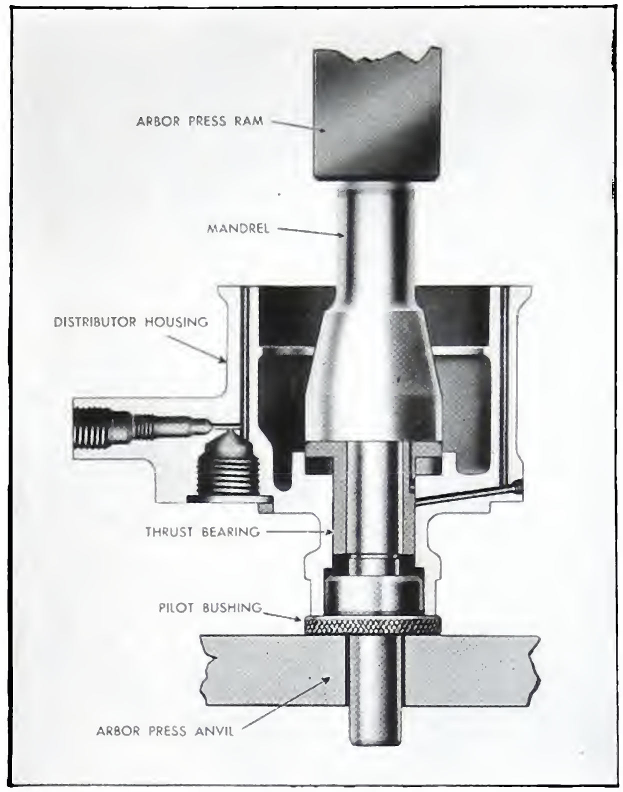


Fig. 5-71. Pressing in thrust bearing

a light even pressure from an arbor press while facing the bearing. A small countersink at the top of the tool will permit using a 3/8" ball bearing between the press ram and tool. Fig. 5-73.

6. The thrust bearing can be faced in a lathe using the bottom of the distributor as a locating point against the lathe face plate fixture.

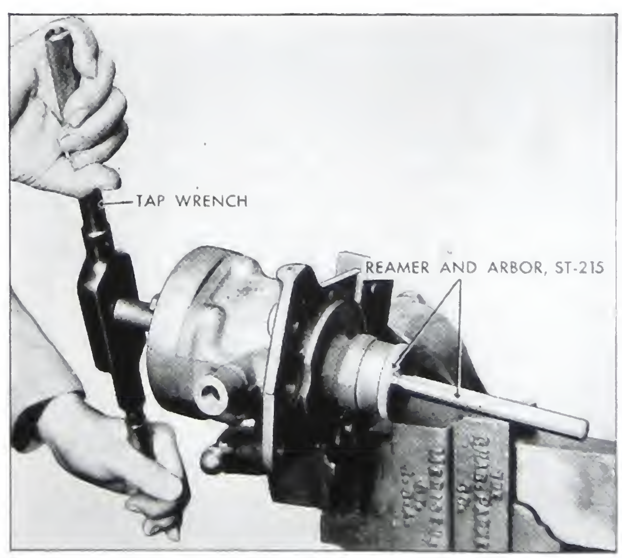


Fig. 5-72. Reaming thrust bearing

Fig. 5-73. Facing distributor thrust bearing

7. Check with Prussian blue between the thrust bearing and the collar. If the bearing has been properly faced, it will be indicated by an even wiping of the Prussian blue around the thrust bearing. Check by turning the distributor shaft only one-third of a turn.

Overspeed Stop Drive Gear: If it is necessary to install a new overspeed stop drive gear, remove the rivets from the old one and rivet a new gear to the distributor drive gear. This gear and the overspeed stop driven gear, No. 62378, must be replaced at the same time.

Ball Bearing: 1. Wash the lower ball bearing in solvent and blow out with compressed air. If it is worn or rough, replace with a new one. Lubricate with lubricating oil.

2. Assemble the distributor, drive shaft and collar assembly to the housing and press the gear in place over the key. Using nesting block, ST-4, or a 1½" x 12 point socket as shown in Fig. 5-74, while pressing the gear in place.

NOTE: Short strokes of the press handle while starting the gear in place on the shaft will help to secure proper alignment. Unless the gear is properly assembled all the way to the stop against the ball bearing, it will be very difficult to assemble the distributor unit to the fuel pump and obtain the right amount of gear lash.

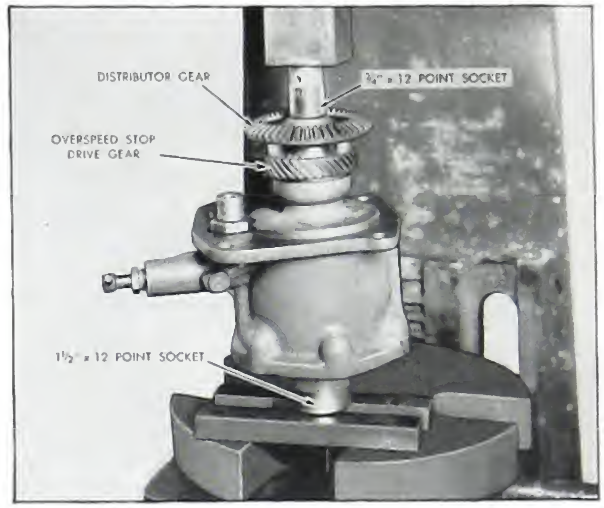


Fig. 5-74. Assembly distributor drive gear

Disc Bushing: 1. Unless the distributor disc bushing or Mogul ring is distorted, or out of alignment, or excessively scored, it should not be removed. If it is found necessary to replace the ring, remove the old ring with a chisel. Clean the housing and ring and remove any burrs. Press the ring in place evenly with the pilot plate of ST-215. Fig. 5-75.

2. The new ring must be scraped in with a bearing scraper to fit the distributor disc. This must be done carefully and frequent checks made for fit. When finished, there should be a minimum .005 clearance around the entire circumference of the disc between the disc and ring. See Fig. 5-76.

Tachometer Shaft: Remove the distributor disc. Place the cover temporarily in place on the fuel pump housing. Watch the tachometer shaft in its guide while turning the fuel pump drive gear. If the tachometer shaft does not turn true, remove the cover and straighten the shaft with light blows from a small hammer.

Disc and Cover: 1. If the disc or cover show scored marks, or if they are badly worn, it will be necessary to replace them with a new, or reground, disc and cover set. Regrinding and lapping is strictly a factory operation because the tolerance required is so close that it is impossible to maintain except with special equipment.

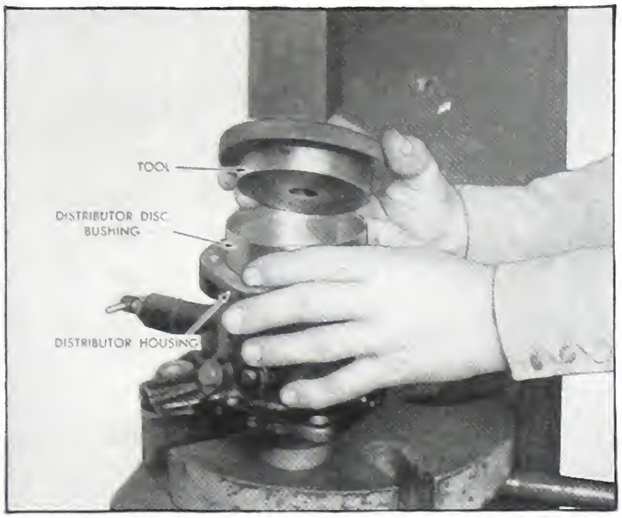


Fig. 5-75. Distributor disc bushing

2. New discs and covers are supplied only in pairs. If the old disc and cover are to be replaced, the new ones should be carefully and thoroughly washed in solvent and all passages blown out with compressed air.

Spring: 1. Place the disc thrust spring on the collar and locate the distributor disc in position on the driving pins. This cannot be put on wrong, due to one pin being offset. Fill the holes in the distributor disc with a high grade SAE No. 20 clean lubricating oil. Also oil the face of the distributor cover. A new gasket of proper design and thickness must be used each time between the distributor top and the housing. Be sure to properly index the holes in the gasket and the housing.

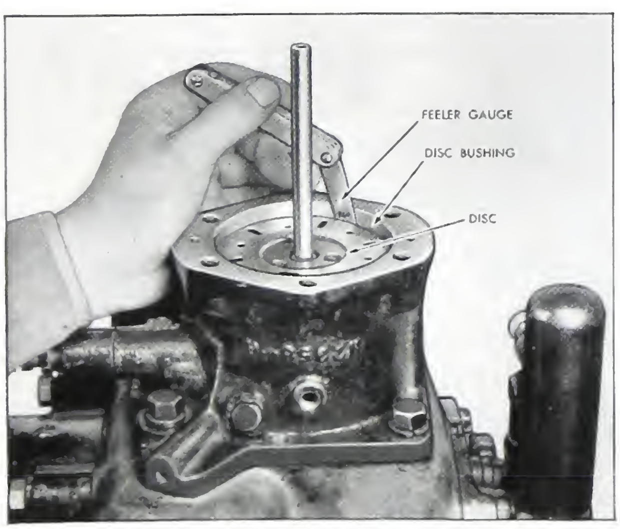


Fig. 5-76. Disc and bushing clearance

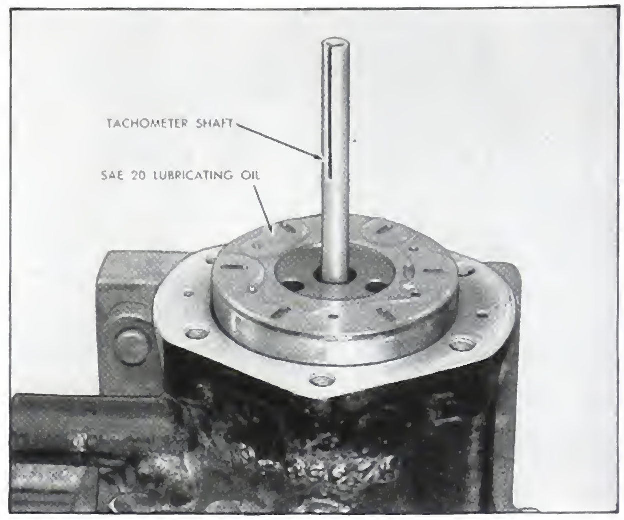


Fig. 5-77. Lubricating the disc

2. It will be necessary to compress the distributor spring by pushing on the distributor tachometer guide to start the capscrews that hold the distributor top in place. When all the capscrews are started by hand, tighten each one alternately, one-half turn at a time, until the cover is down against the gasket and distributor housing. If the distributor cover is not tightened down evenly, it will catch the distributor disc bushing and push it down on one side. This will break the seal between the distributor top and disc, and after starting the engine, the flow of fuel to the metering pump will be disrupted.

Timing Mark: Turn the distributor shaft until the timing mark on the collar shows through the inspection hole.

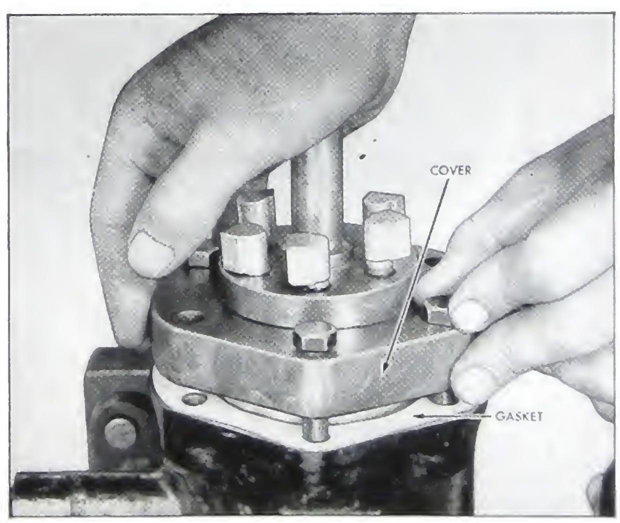


Fig. 5-78. Assembly distributor cover

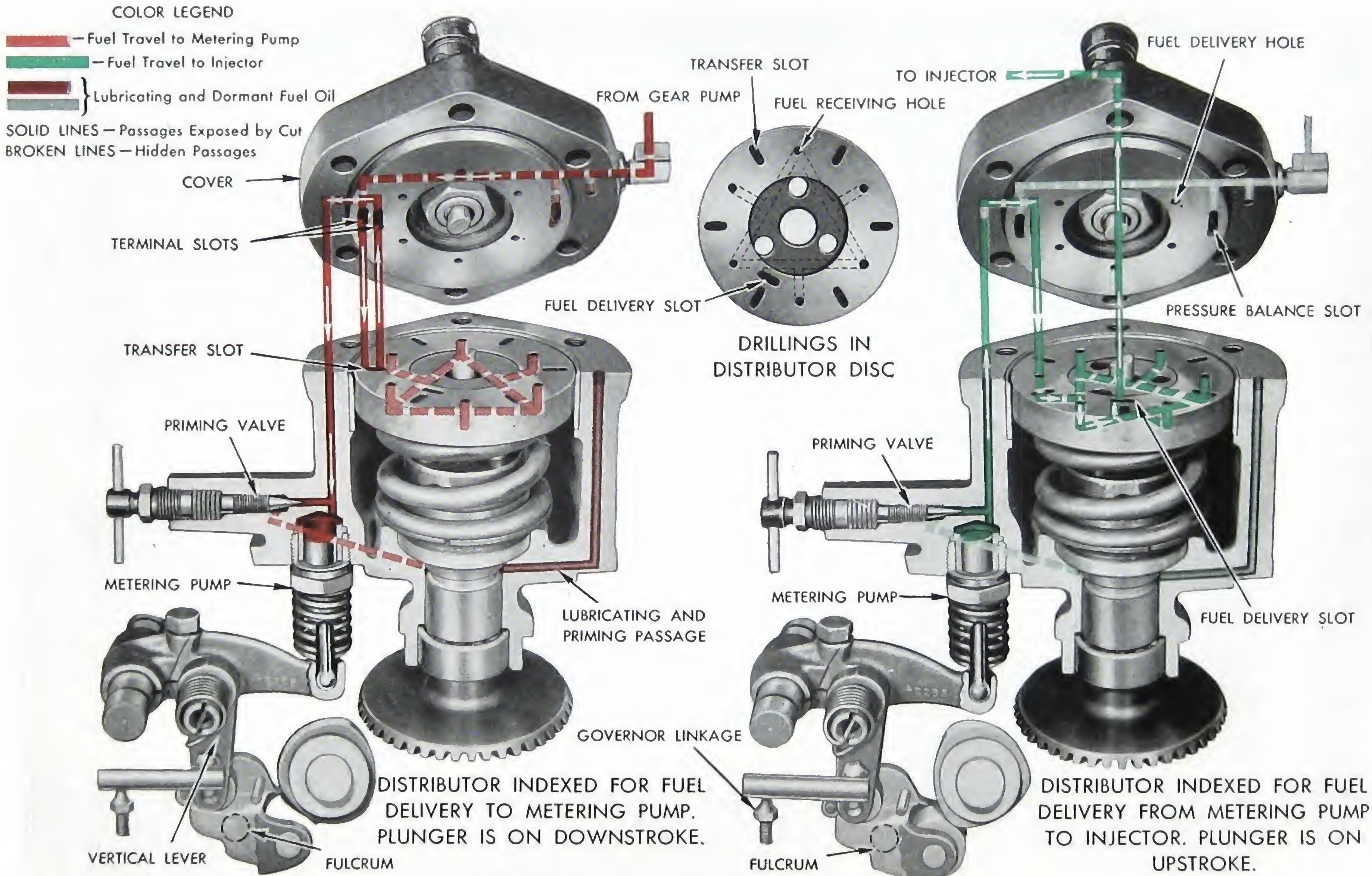


Fig. 5-79. Fuel flow through distributor to injectors

GEAR PUMPS: Perform such of the following repair operations as indicated by inspection and assemble.

Gear Pockets: 1. Use facing cutter, ST-148, to recut gear pocket. This tool is adjustable for depth but by using a hardened .125 spacer plate it can be used to cut the No. 1 gear pockets without changing the .500 depth setting. The cutters should be reground when necessary by precision grinding to 5° rake angle for hand cutting.

2. Restore uniform gear pocket depth to same dimension as width of gears by lapping bodies on a surface plate. Fig. 5-81.

CAUTION: WASH THE BODY THOROUGHLY OF ALL LAPPING COMPOUND AND DRY WITH AIR BEFORE FITTING GEARS TO THE BODY.

3. Follow the same procedure for both the Number 1 and Number 2 gear bodies.

Drive Shaft: 1. Place the longer Woodruff key in the slot on the gear pump drive shaft farthest from the drive end. Push the lock ring on the shaft to the slot with the opening of the lock ring held in place by the Woodruff key. Fig. 5-82.

2. Assemble the Number 2 pump gear over the Woodruff key and press it to the lock ring. The lock ring fits into the recess of the gear. (Fig. 5-83).

3. Press the idler gear on the shoulder of the shaft until the short end of the shaft protrudes from the idler gear the same distance as the corresponding end of the drive shaft from the drive gear. Fig. 5-83.

Fig. 5-80. Facing gear pocket with ST-148

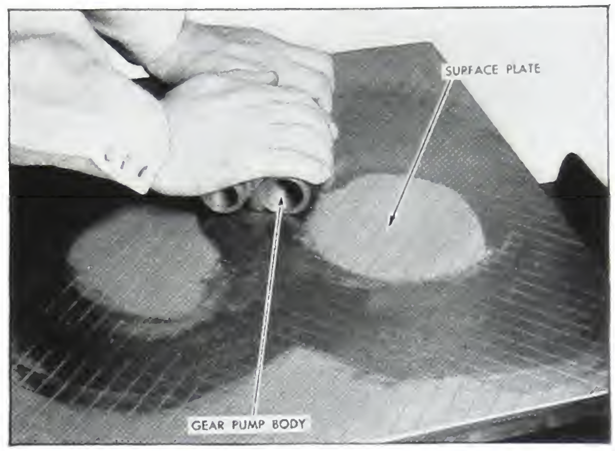


Fig. 5-81. Lapping gear pump bodies

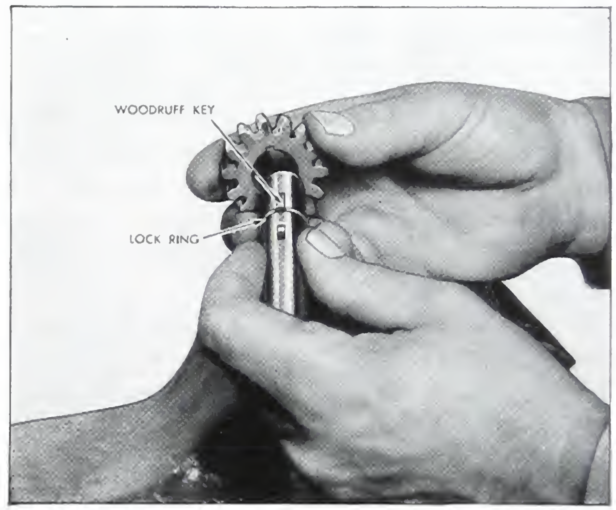


Fig. 5-82. Drive shaft key and lock ring

Lubricating Holes: 1. With a small wire or punch, clean out the small lubricating holes to both sets of gear pockets in the Number 1 and Number 2 gear bodies. These holes not only supply lubrication to the shafts and gears, but also provide balanced pressure against the gears in their pockets to prevent scoring. See Fig. 5-84.

2. If old bodies do not have these drilled holes, drill them 1/16 x 45°, to break out at the bottom of the shaft holes. Also use a cape chisel to cut a slot from the pressure relief pocket to the drive shaft hole in No. 1 body as shown in Fig. 5-84 and as machined in late style housings.

CAUTION: REMOVE BURRS TO AVOID PUMP FAILURE.

Shaft Seals: 1. Caution must be used when assembling new gears to the spacer plate and shaft

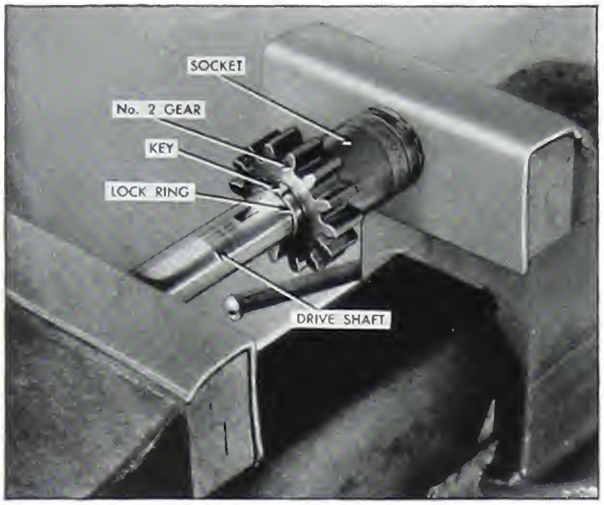


Fig. 5-83. Assembly idler gear on shaft

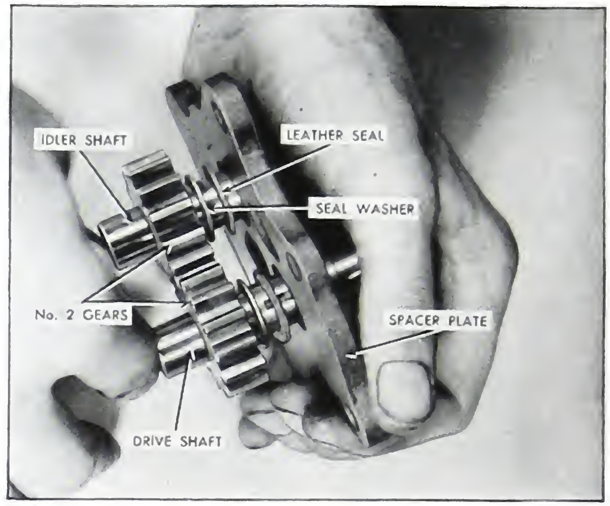


Fig. 5-85. Assembling gear seals

to make sure that the shaft seals are assembled properly. These seals must be assembled on the Number 2 side of the spacer and with the seal washers working against the Number 2 pump. The Number 2 pump is the one with the wide face gears.

2. Assemble the gears and shafts to the spacer plate with the deeper counterbores in the spacer plate to receive the leather seal and seal washer. Always use a new leather seal. The drive shaft fits in the hole located between the two dowel holes in the spacer plate. Fig. 5-85.

Assembly to Spacer Plate: Assemble the Number 1 drive gear to the shaft over the key as shown. It must be assembled as a push fit. If it is too tight to push on with the fingers, file the sides of the key carefully until the proper fit is obtained. Fig. 5-86.

Rocker Lever Bushing: Pull the worn cam rocker lever bushing from the No. 1 gear pump body with a 11/16" tap screwed into the bushing. Press a new bushing in place.

Oil Seal: Insert a new drive shaft oil seal in the No. 1 body with a plug and guide to prevent the sealing lip from being turned and the seal being damaged. Assemble the sealing lip to the pressure side. Fig. 5-87.

CAUTION: CARE MUST BE USED TO PREVENT DAMAGE TO THIS SEAL WHILE ASSEMBLING THE NUMBER 1 BODY ON THE SHAFT. A DAMAGED SEAL

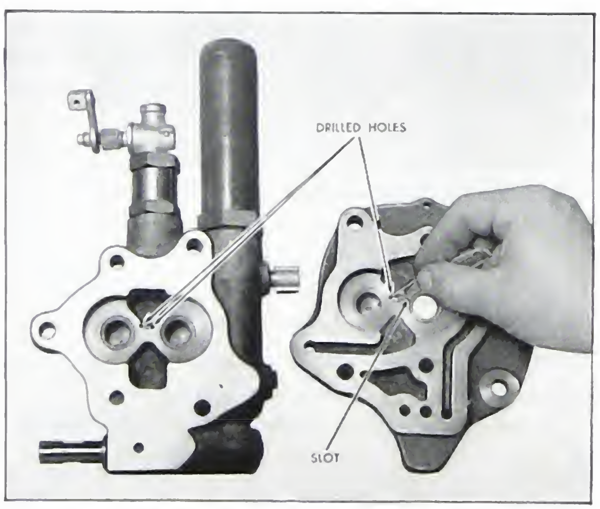


Fig. 5-84. Drilled holes for lubrication

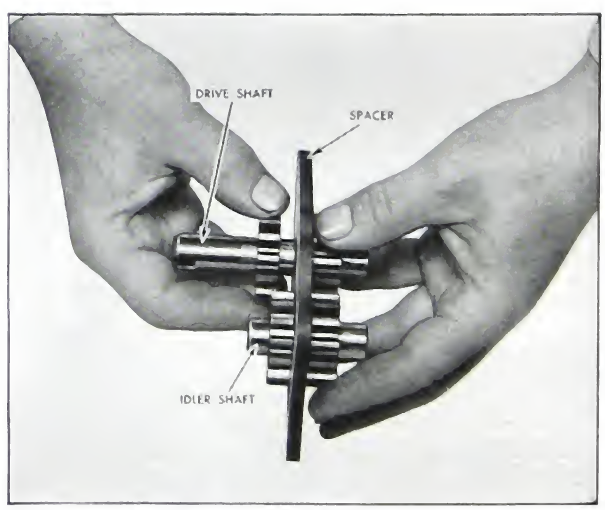


Fig. 5-86. Assembling gears to spacer plate

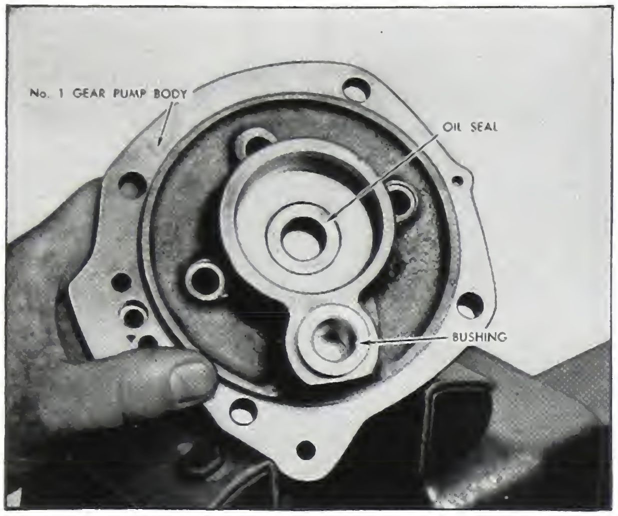


Fig. 5-87. Drive shaft oil seal

WILL RESULT IN LEAKAGE FROM NO. 1 PUMP TO MAIN HOUSING.

Gaskets: 1. Brush a thin coat of No. 3 Permatex on the spacer plate gasket surface only, always being careful not to get the Permatex in the gear pockets and fuel passages. Place a .0015 gasket in proper position. Brush a thin coat of No. 3 Permatex on the assembled gasket, being very careful not to brush closer than 1/8" to gear pockets.

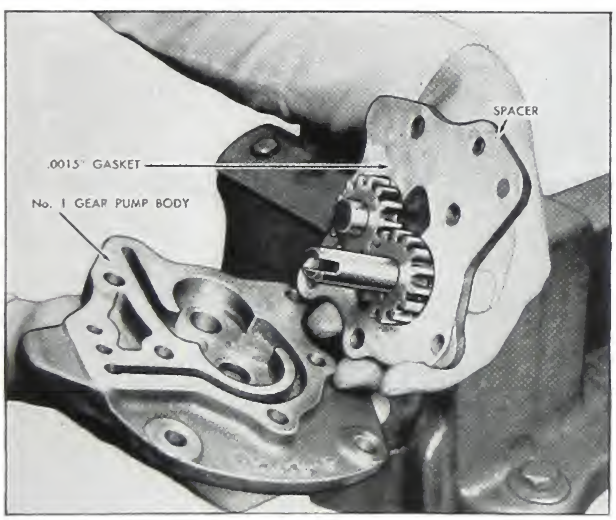


Fig. 5-88. Assembling Number 1 gears and body

2. Lubricate the gear pockets with S.A.E. 20 lubricating oil. Install the gears and spacer plate assembly to the Number 1 body. Fig. 5-88.

Screw: With the gears, spacer plate and gasket properly assembled to the Number 1 body, insert the fillister head screw just tight enough to hold the assembly together. (Fig. 5-89).

Gasket: 1. Brush a thin coat of No. 3 Permatax on the Number 2 body gasket surface, being careful not to get the Permatex closer than to within 1/8" of the gear pockets. Place the gasket in position and put a thin coat of Permatex on the gasket. (Fig. 5-90).

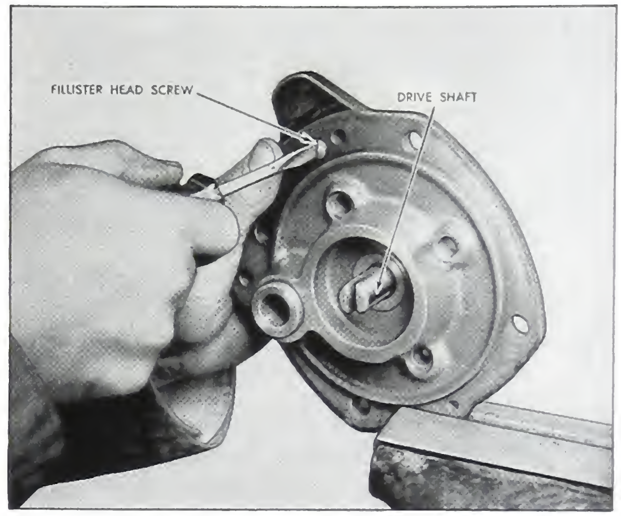


Fig. 5-89. Fillister head screw

2. Place the Number 2 body and gasket over the gears in position against the spacer plate.

Pump Bodies: 1. Insert the mounting capscrews through both pump bodies and attach the 3/8" nuts to the protruding ends. While pulling these nuts tight, turn the drive shaft to see that the pump gears continue to turn freely. If necessary, tap the edges of the bodies to free the gears.

2. Drive the two dowel bolts in place from the

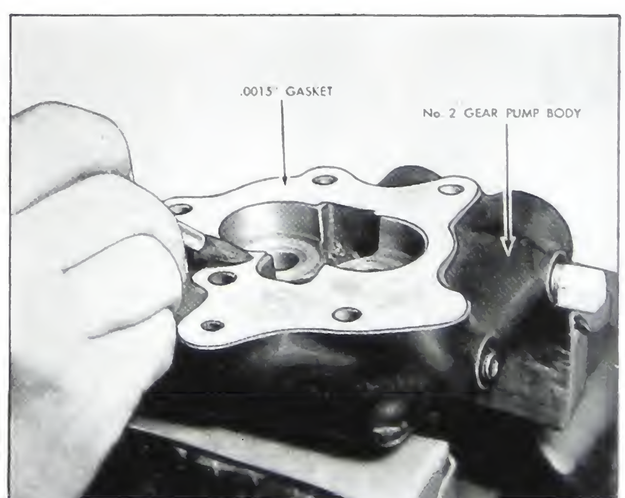


Fig. 5-90. Permatex on gasket

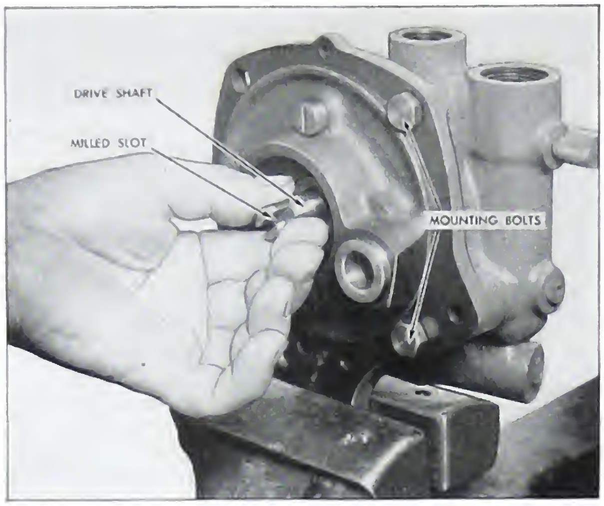


Fig. 5-91. Testing gear pump

back. Tighten nuts on the assembly bolts to 30 foot pounds with a torque wrench. Tighten the fillister head screw with a heavy-duty screwdriver.

Testing: The gear pump drive shaft should turn by finger grip only. If it will not, loosen the bolts slightly and strike the body lightly with a small hammer while continuing to turn the gear pump drive shaft until it turns freely. Retighten and recheck. See Fig. 5-91.

Fuel Check Valve: 1. Drop the fuel check valve, with the tip end down, into the smaller of the two bores above the Number 2 gear. Test for free fit.

2. If screen is damaged replace and solder to nut, or replace screen and nut as an assembly.

3. Hold the fuel supply check valve housing

Fig. 5-92. Fuel supply check valve assembly

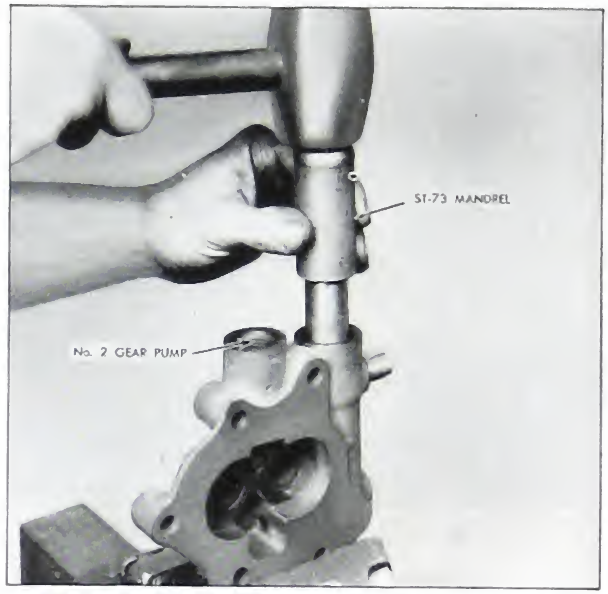


Fig. 5-93. Installing regulator valve sleeve with ST-93

in inverted position in a vise. Drop the fuel supply check valve guide, open end up, into the housing. Place the spring into the guide. Place the fuel supply check valve, open end up, on the spring and in the guide. Assemble the check valve housing with the proper gasket to the

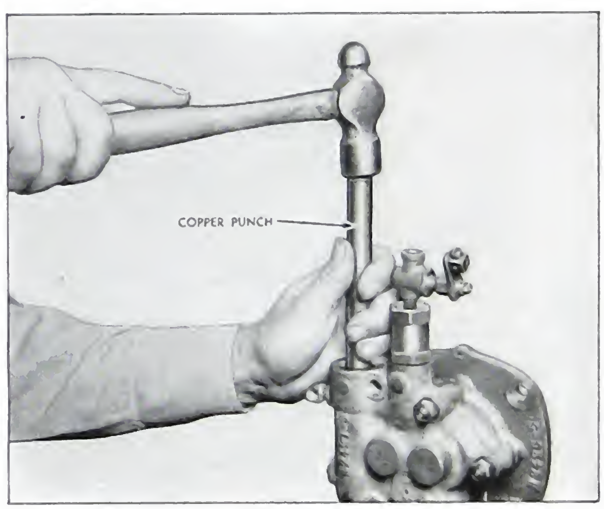


Fig. 5-94. Seating ball check

check valve seat assembly. See Fig. 5-92 and 5-96.

Valve Sleeve: Install a new pressure regulating valve sleeve, No. 9134-1, in place of the old one, if removed, using mandrel, ST-73. This mandrel has a stop to insure that the sleeve will be assembled to the right depth.

Check Ball: 1. Drop the check ball into the

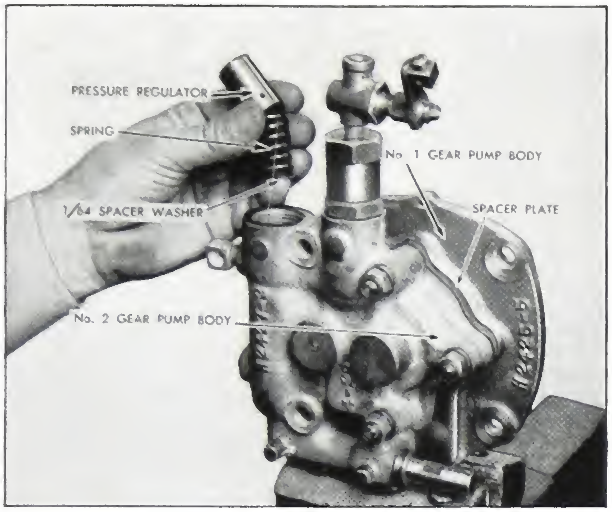


Fig. 5-95. Pressure regulator assembly

pressure chamber side of the housing and seat with a copper punch and small hammer.

Regulator Valve: 1. Install new or used pressure regulator valve as indicated by inspection.

2. It is sometimes necessary to add 1/64" washers below the pressure regulator spring to increase the spring pressure. One washer increases maximum fuel pressure approximately 10 pounds. Adding washers will not correct low pressure at slow speeds due to leaking gear

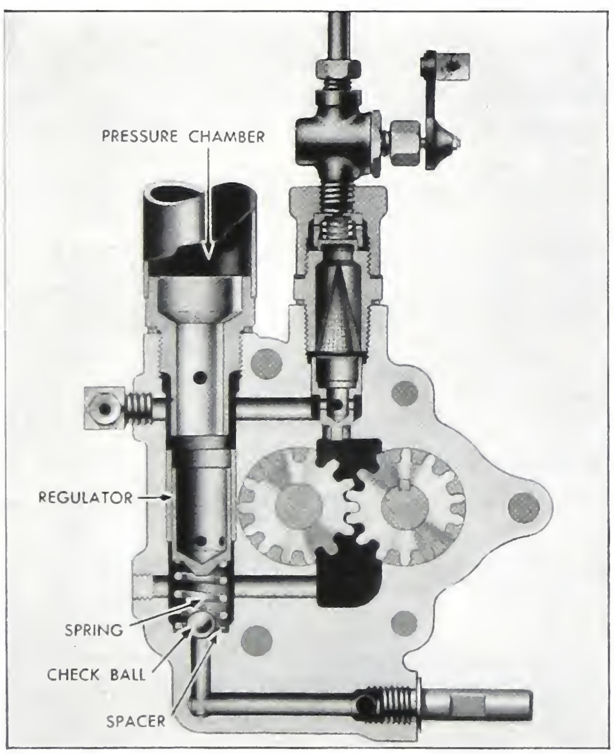


Fig. 5-96. Number 2 pressure pump and regulator

pumps. Its effect is to increase the maximum pressure at the governed speed. Required pressures are given in "TESTING AND CALIBRATING" section, Page 5-101.

3. Place the pressure regulator spring in the housing.

4. Slide the pressure regulator into place with the point down toward the check ball. Check to be sure the regulator works freely.

NOTE: If the pressure regulator sticks and remains open, it will cause a drop in fuel pressure. If it sticks and remains closed, it will cause excessive fuel pressure.

Pressure Chamber: Screw the pressure chamber into the body, making sure that the gasket is in good condition.

Idling Control Lever: 1. Assemble the idling control lever in place on the shaft and secure with the washer and 1/8" cotter pin.

2. Lay the gear pump aside until repairs are made on remaining fuel pump units.

The No. 1 gear pump draws fuel from the fuel supply tank and delivers it to the float chamber. The No. 2 gear pump draws fuel from the float chamber and delivers it to the distributor. Both gear pumps are equipped with by-pass valves that permit recirculation of "surplus" fuel. (See Figure 5-98).

FLOAT CHAMBER: 1. Clean all parts thoroughly with solvent and dry with compressed air.

2. Place the small dowel pin in the float chamber top plate, making sure that it is tight enough not to drop out.

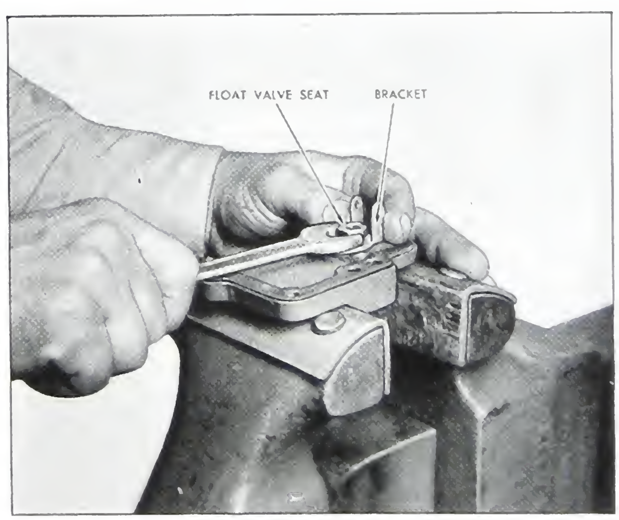


Fig. 5-97. Installing float valve seat

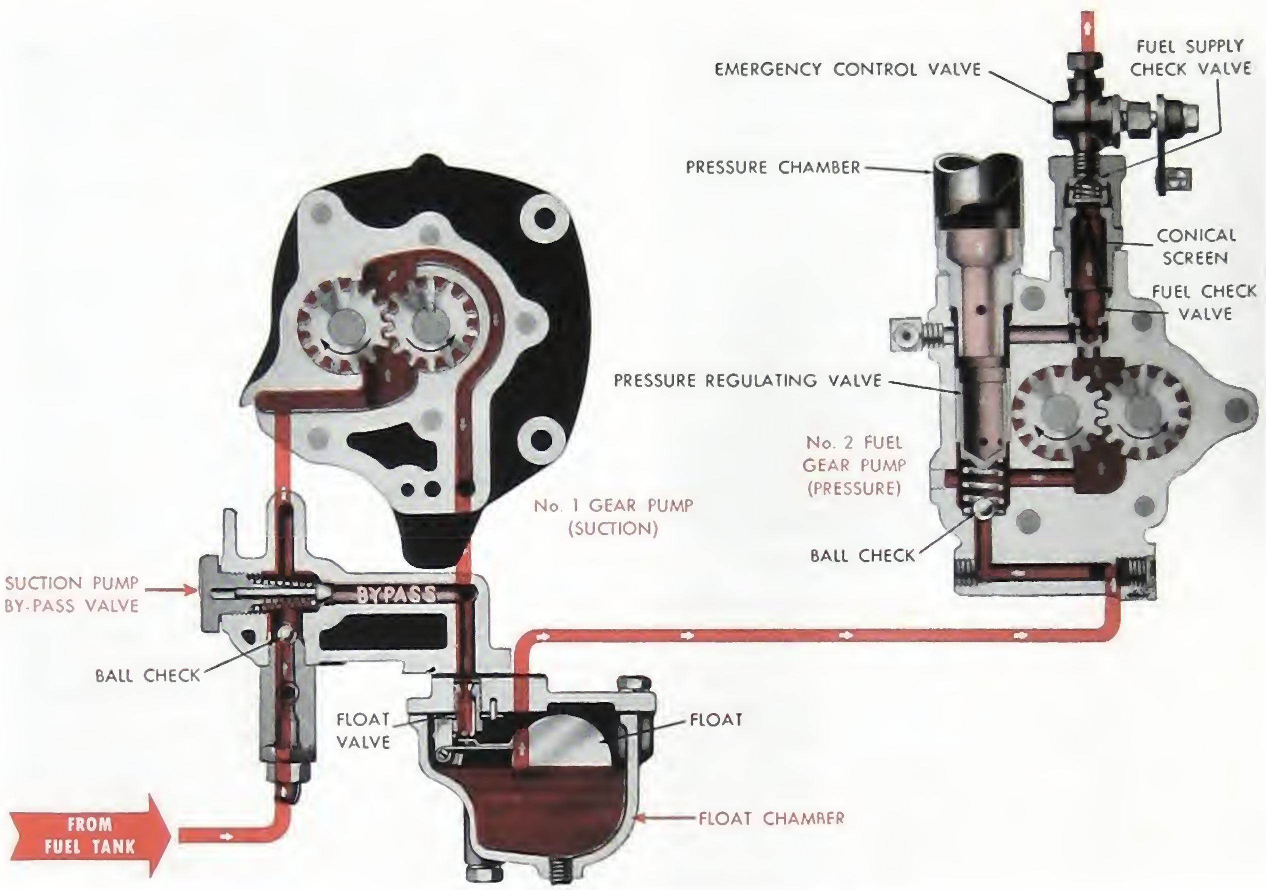


Fig. 5-98. Fuel flow from tank to distributor

3. Place the gasket in position on the top plate.

4. Place the float bearing bracket in position on the dowel pin.

5. Install the float valve seat with a new gasket and tighten securely. Fig. 5-97.

6. Make sure the float valve is free of burrs and in good condition. Drop it into place and seat by tapping lightly with a small hammer while holding a screwdriver against the shoulder of the float valve. Fig. 5-99.

7. Place the float in position and insert the

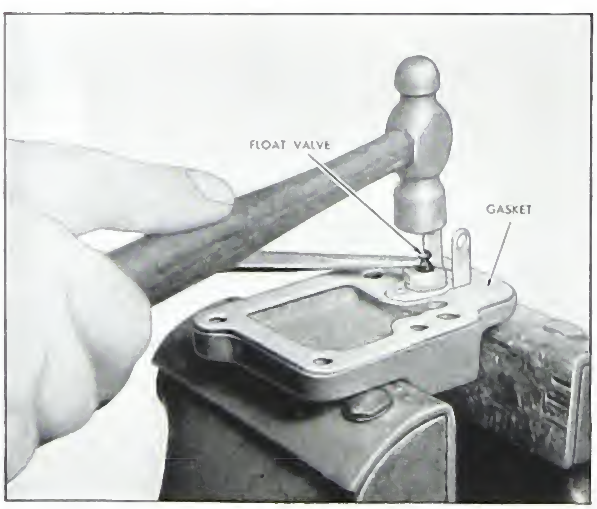


Fig. 5-99. Seating float valve

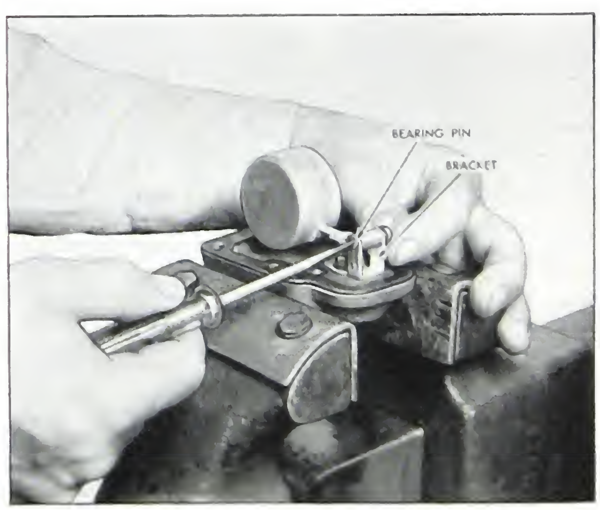


Fig. 5-100. Float assembly

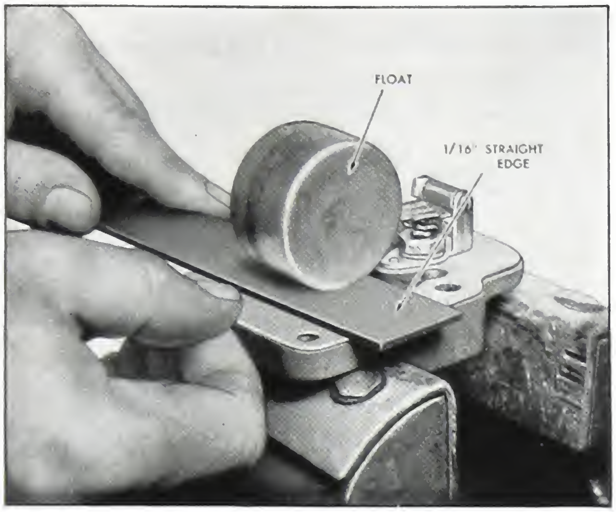


Fig. 5-101. Float clearance

bearing pin. Place the float stop in position and assemble the lockwasher and nut to the bearing pin.

8. Make sure the float and valve are absolutely free and that the float contacts the head of the valve, holding it firmly on the seat in closed position. Otherwise the fuel will overflow at the bottom of the pump. The float should have 1/16" clearance as measured with a straight edge between the float and gasket surface. (Fig. 5-101).

9. Assemble the float chamber to the top plate.

FUEL PUMP HOUSING—*Needle Bearings:* 1. To replace needle bearings, spread a clean cloth on the work bench and on it place the parts of the vertical lever to be assembled.

2. ST-6 is a tube and arbor needed to assemble the needle bearings.

3. Place the roller on the index finger and put the arbor of ST-6 in the hole. Fill the hole with 22 long needle bearings. (Fig. 5-102).

Roller: 1. Place the roller, plug and needle bearings in position in the vertical lever. Push the roller pin through the lever and roller. This will cause the small plug to fall out on the opposite side.

2. Lock the pin in position by riveting the copper rivet into the grooves on both sides of the vertical lever. File the rivet flush with the side of the vertical lever. (Fig. 5-103).

Plunger Lever: 1. To assemble the plunger lever pin, use copper tubing of ST-6 to receive the needle bearings. Place the plunger lever between the arms of the vertical lever in position.

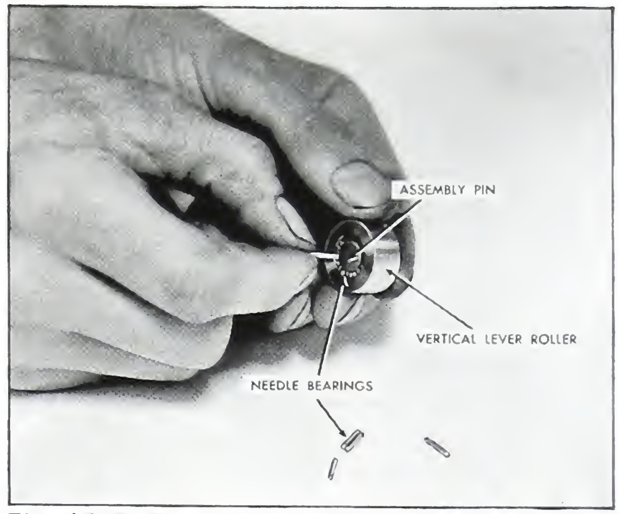


Fig. 5-102. Vertical lever roller and needle bearings

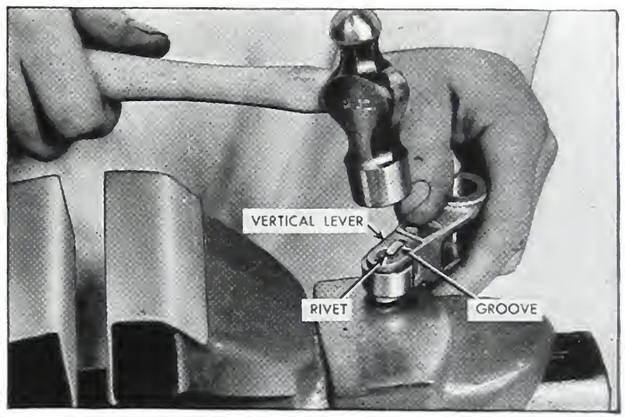


Fig. 5-103. Assembling vertical lever and roller

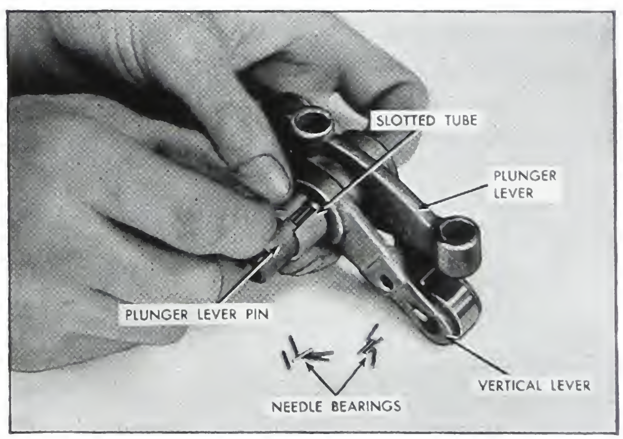


Fig. 5-104. Assembling plunger lever pin and needle bearings

CAUTION: THE VERTICAL LEVER MUST BE ASSEMBLED TO THE PLUNGER LEVER SO THE FLAT SIDE WILL BE NEXT TO THE BALL JOINT LINK TO INSURE THE ROLLER OF THE VERTICAL LEVER LINK ENGAGING PROPERLY IN THE CAM ROCKER RADIUS. (Fig. 5-104).

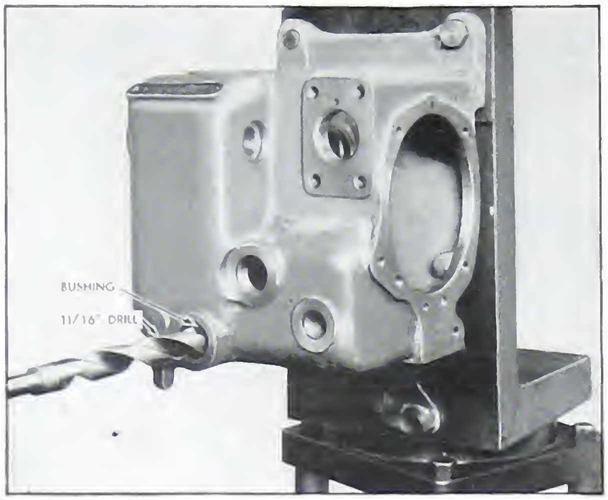


Fig. 5-105. Removing shaft bushing

2. Tap the plunger lever pin through the vertical lever and plunger lever, leaving the needle bearing race open on one side. Place the slotted tubing over the pin and insert 28 short needle bearings.

3. Tap the plunger lever shaft through far enough to allow the opposite bearing race to be filled with the same number of needle bearings.

4. Push the plunger into position and turn the groove in the pin to match the capscrew hole in the plunger lever. Run the capscrew down loosely to hold the pin in place.

5. Test the action of the vertical lever and roller on their bearings. Each of the component parts of the vertical lever and plunger lever assembly must work absolutely free after assembly to the main housing.

Bushings: 1. Remove old bushings as indicated necessary by inspection. Drive them out with proper mandrels as listed in table below. Before driving out the control shaft bushing, No. 62351, it will be necessary to remove the oil seal and cut off the collar with a 11/16 drill as shown in Fig. 5-105. (Hydraulic only)

2. Install all new bushings in fuel pump housing for those removed except governor control rod bushing, No. 60466-S. Use the proper service tools for the bushing as indicated below. Other service tools for these bushings shown in the table will be referred to in following paragraphs.

3. All reamers with No. 1 Morse taper referred to in bushing table should be driven with driver, ST-137. This driver also serves as a pilot for most of these reamers.

4. Fixture, ST-109, is a reaming and assembly

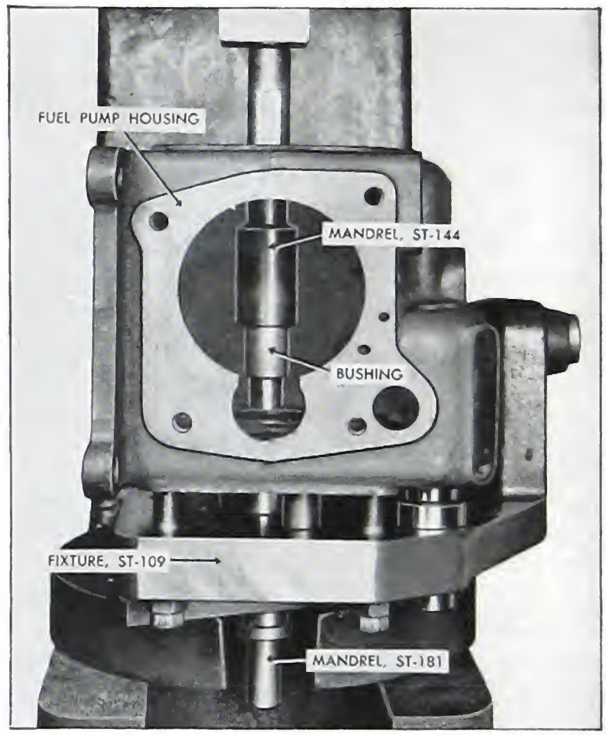


Fig. 5-106. Installing governor control rod bushing

BUSHINGS IN FUEL PUMP HOUSING

PART NO.	NAME OF BUSHING	Mandrel	Fixture	Reamer	Finish Dimension
9124-2S	Cam rkr. lever bushing	ST-140	ST-209	ST-143	.812/.8125
62351	Control shaft bushing	ST-135	ST-109	ST-141	.4995/.5005
60466-S	Gov. con. rod bushing	ST-208			
		ST-181	ST-109	ST-177	.6262/.6272
		ST-144			
69004	Hand con. ecc. ndl. brg. (2)	ST-142		(for shaft)	.5625/.563
9144-S	Plunger lever shaft bushing	ST-138	ST-109	ST-276	.749/.7495
9125-S	Plunger lever shaft bushing	ST-138	ST-109	ST-276	.749/.7495
S-16046-A	Gov. lever ndl. bearing (2)	ST-135			.4995/.500

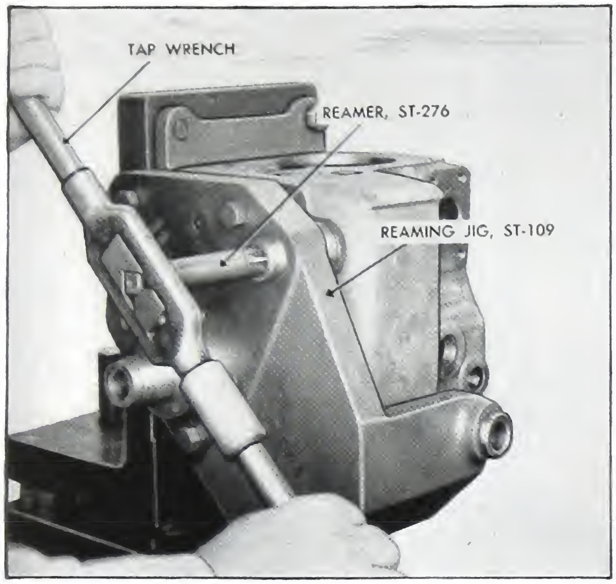


Fig. 5-107. Reaming plunger lever shaft bushings

fixture. Assemble it carefully to the housing and pull up the three assembly capscrews evenly to approximately 30 foot pounds. Pads must rest squarely against milled face of housing.

5. Put mandrel, ST-181, in fixture, ST-109, and assemble governor control rod bushing on ST-181 mandrel. Use mandrel, ST-144, to press the bushing in the housing as shown in Fig. 5-106.

6. Use a tap wrench as a driver for reamer ST-276 to ream both plunger lever shaft bushings as shown in Fig. 5-107.

CAUTION: NEVER REVERSE TURN A REAMER. THIS WILL INVARIABLY DULL THE CUTTING EDGE.

7. The use of lubricating oil on hand reamers will generally insure a better finish and longer reamer life when working in bronze. Always use service bushings, designated by suffix "S", for

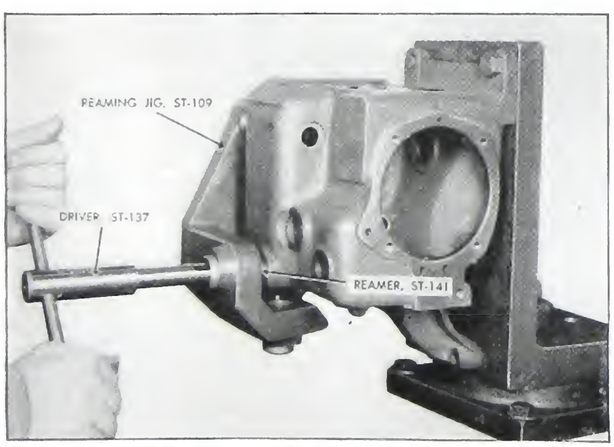


Fig. 5-108. Reaming control shaft bushing

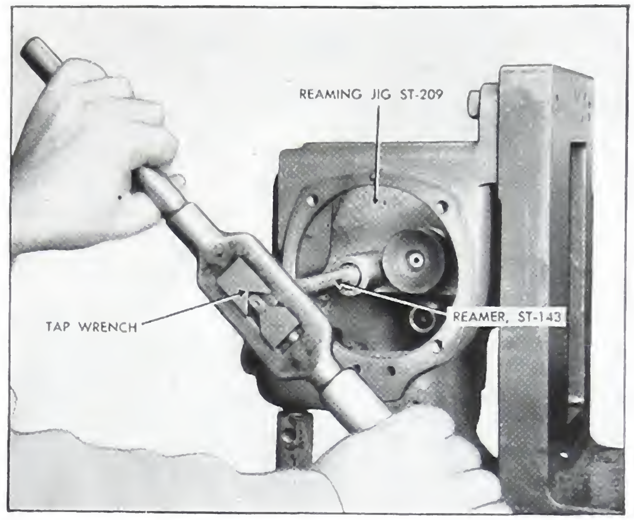


Fig. 5-109. Reaming cam rocker lever bushing

minimum reaming stock and longer reamer life.

8. Finish ream all remaining bushings in the fuel pump housing except the cam rocker lever bushing. Use Fixture, ST-109, driver, ST-137, and reamers as listed in bushing table following Step 5. Fig. 5-108.

9. Remove Fixture, ST-109, and install Fixture, ST-209, in main housing. Locate with knurled hand nut and plunger lever pin. Ream with bottom reamer, ST-143, and drive with ½" square shank socket and T wrench as shown in Fig. 5-109.

10. Use a bearing scraper to remove all burrs from ends of reamed bushings.

Hand Control Eccentric Bearings: All current production fuel pump housings have two needle

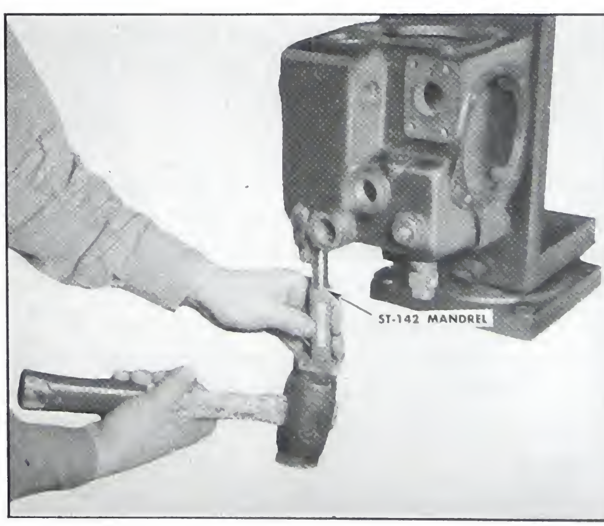


Fig. 5-110. Installing hand control eccentric bearing

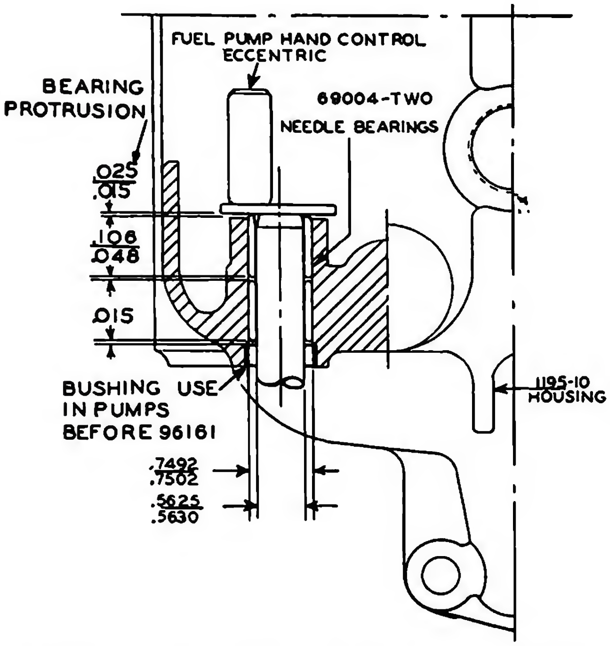


Fig. 5-111. Hand Control Eccentric Needle Bearings

bearings, No. 69004, for the hand control eccentric in place of the bronze bushing, No. 9959, formerly used. Needle bearings should be installed in all old-style housings as the fuel pumps are rebuilt by the following method:

1. Enlarge the bearing bore in the fuel pump housing by drilling with a 47/64" drill and reaming to .7492/.7502.

2. Use ST-142 driving mandrel and spacer to install two needle bearings with smooth end up as shown in the sketch, Fig. 5-111.

3. Fuel pumps before Serial No. 96161 should have a 70535 bushing pressed into the housing to the bottom of the counterbore. New housings are not counterbored. Fig. 5-111.

Governor Lever Bearings: The governor lever—as made currently—is fitted with two S-16046 needle bearings instead of the bronze bushing formerly used. The change was made to prevent fall-off in fuel delivery caused by wear of the bronze bushing. The governor levers used in all rebuilt fuel pumps should have needle bearings. To install needle bearings in an old governor lever:

1. Drill the governor lever bore to 43/64" and ream to .6865/.6875.

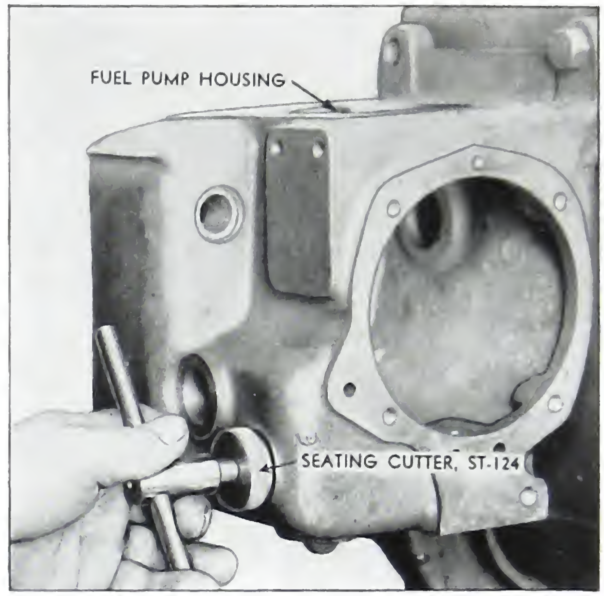


Fig. 5-112. Refacing by-pass valve seat

2. Use a .500 mandrel and a 1/32" spacer to press needle bearings in the governor lever—one from each end—so that each bearing is 1/32" from the end of the bore.

By-Pass Valve: The by-pass valve spring must exert enough pressure to insure a supply of fuel to the float chamber, but if it is too strong the fuel will overflow at the main housing. The spring should compress to 1 19/64 at .410 pound. However, it is best to check fuel by-pass springs during the fuel pump test rather than attempt to pass or discard them from a weight test. If the seat needs recutting, use seating cutter, ST-124, to

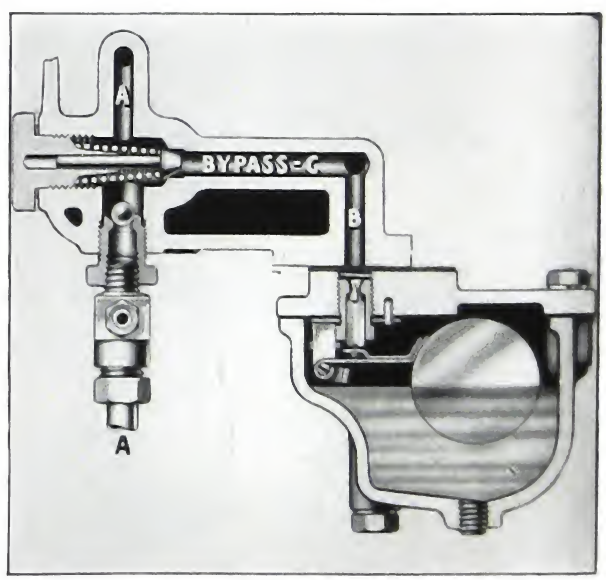


Fig. 5-113. Fuel pump float chamber and by-pass

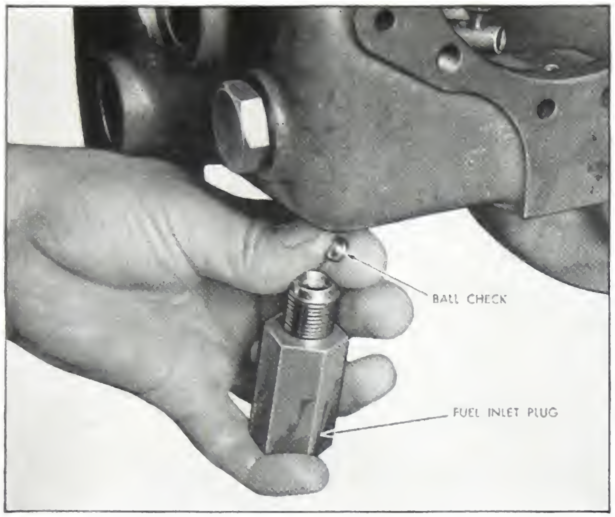


Fig. 5-114. Fuel inlet plug

remove just enough material to clean up the seat. Fig. 5-112. Check with Prussian blue. It may be necessary during fuel pump test to add a washer or spacer to compensate for metal removed. Sometimes a slight blow against an assembled valve with a small hammer will help to seat the valve.

Fuel Inlet Plug: 1. Remove the fuel inlet plug at the main fuel inlet, being careful not to lose the ball check. Clean and inspect the seat. Install the check valve and seat at the main fuel inlet. (Fig. 5-113).

2. Cross section view of float chamber, fuel inlet plug and by-pass valve in position (Fig. 5-113) will help make by-pass valve function apparent.

Cam Rocker Lever: 1. Remove any burrs from the roller pin holes in the cam rocker lever to avoid shearing the pin. Start the roller pin into the lever after making sure the oil hole in the pin is open. Fig. 5-115.

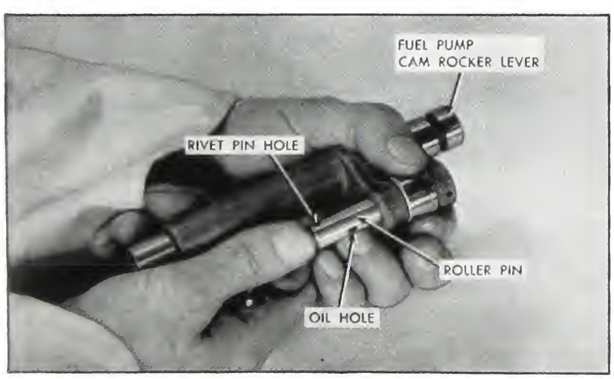


Fig. 5-115. Cam rocker lever

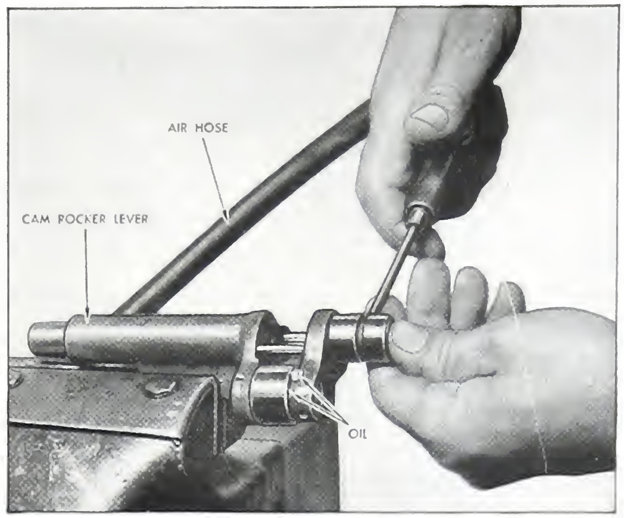


Fig. 5-116. Oil passages

2. Assemble the roller in place and drive the pin through the cam rocker lever and roller, indexing the lubricating hole in the pin with the hole in the lever.

3. Insert a rivet pin through the roller pin and peen it in place.

4. As a final check for open oil passages to the roller, place a few drops of lubricating oil between the roller and cam rocker lever arms. Blow compressed air through the oil passages from the shaft. Bubbles will indicate open passages.

Stop Sleeves: One fuel cam rocker lever, No. 5472-1 is currently used on all H, HS, NH and NHS fuel-pumps. Different vertical lever stop pin sleeves are used for each of the above pumps. The function of the sleeve is to provide an internal fuel stop to prevent a large excess fuel delivery. Combinations of fuel cams and sleeves for

Engine	Cam R'kr. Lever	Sleeve	Sleeve O.D.	Fuel Cam.
H-4	5472-1	64264	.558/.560	4822
H-4	5472-1	*69033	.480/.482	4822
HR-4	5472-1	67592	.438/.440	4822
HR-4	5472-1	*69034	.394/.396	4822
H-6	5472-1	64264	.558/.560	4771-1
H-6	5472-1	*69033	.480/.482	4771-1
HS	5472-1	67850	.432/.434	4771-1
HS	5472-1	*68454	.320/.322	4771-1
HR	5472-1	67592	.438/.440	4771-1
HR	5472-1	*69034	.394/.396	4771-1
HRS	5472-1	68199	.489/.491	41812-1
HRS	5472-1	*68453	.404/.406	41812-1
HRBB	5472-1	69034	.394/.396	4771-1
NH	5472-1	67592	.438/.440	4771-1
NHS	5472-1	67595	.509/.511	41812-1
* Use Only With Drilled Distributor Disc Cover				
NOTE:	Old Style			
H	4767	67862	.1875/.188	4771-1

each pump model is given in the table. Provide the proper combination for the model pump.

GOVERNOR AND MAINSHAFT—Mechanical: Replace worn with new parts as indicated necessary by inspection and rebuild governor housing, governor and mainshaft assembly as detailed in succeeding paragraphs.

Housing Bushing: To replace the governor housing bushing, No. 9114-2S:

1. Press out the old bushing and press in a new service bushing flush with inside of boss with mandrel, ST-229.

2. Assemble the governor housing to the reaming fixture, ST-222, and push sliding arbor into position.

3. ST-223 is a special expansion reamer made to pilot in ST-222. Make sure reamer is properly set and ream bushing to 1.625/1.626. Lubricating oil will help insure a good finish.

4. Blow all shavings from oil passages. Try the yoke in the newly reamed bushing and gauge for exact size with plug gauge, ST-210.

Gear Pump Drive Pin: To replace gear pump drive pin, No. 9178-1, in the fuel pump mainshaft, press out the old pin and press in a new one. Use a slotted gear pump drive shaft to line up the new drive pin before peening. Binding would cause the gear pump to score.

Fuel Cam: Press the proper fuel cam for the pump on the shaft over the key and all the way to the shoulder.

Ball Bearings: 1. Press the ball bearing, S-16001, on the shaft with the shielded side next

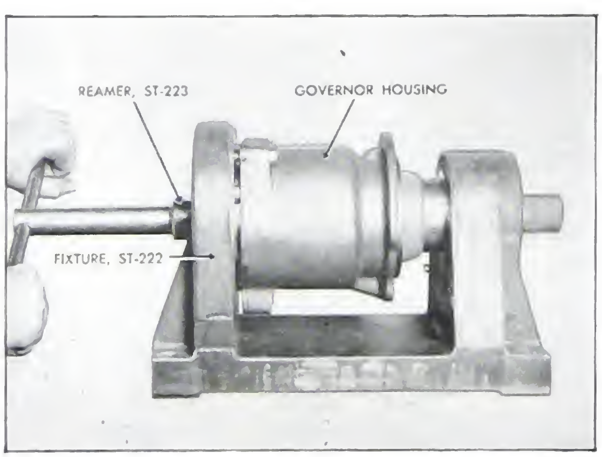


Fig. 5-117. Reaming governor housing bushings

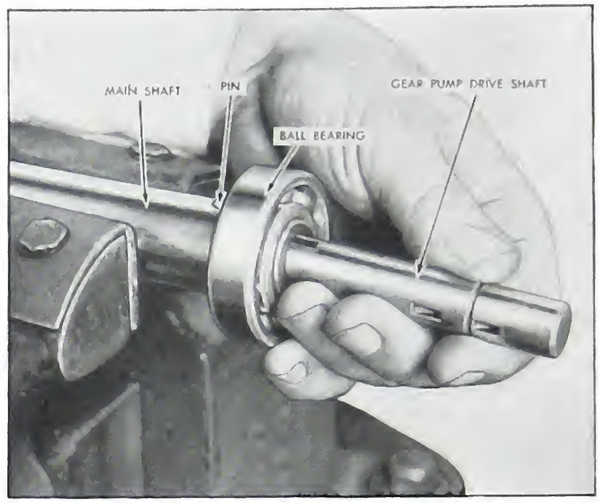


Fig. 5-118. Testing drive pin location

to the cam and assemble the lock ring in place.

2. Press the smaller ball bearing, S-16002, on the gear pump end of the shaft.

Control Rod and Collar: If both the governor control rod and governor control sleeve collar must be replaced new, they should be secured as an assembly, BM-31.

Yoke Tube: Late style governor yoke tube, No. 9104-5, has four 3/32" drilled holes in the collar end of the tube to prevent loss of lubricating oil through the ball bearing and into the main housing. The late style tube also has two reliefs on the outside bearing surface to improve idling characteristics. Old tubes can be machined in the same manner.

Weight Pin Bushings: If inspection has shown it necessary, remove the weight pin bushings, replace them with new ones and ream to .236 with special reamer, ST-203.

Springs: Assemble the maximum speed spring to the governor yoke sleeve. Put the governor spring sleeve in place. Compress the spring with spring compressor, ST-105, and secure the spring sleeve on the yoke sleeve with colletts.

Control Rod and Collar: Assemble the governor control rod and collar assembly to the governor yoke sleeve with the governor thrust ring in position. Lock in place with the snap ring.

Oil Seal: Install a new governor spider oil seal in compressor type governor housing.

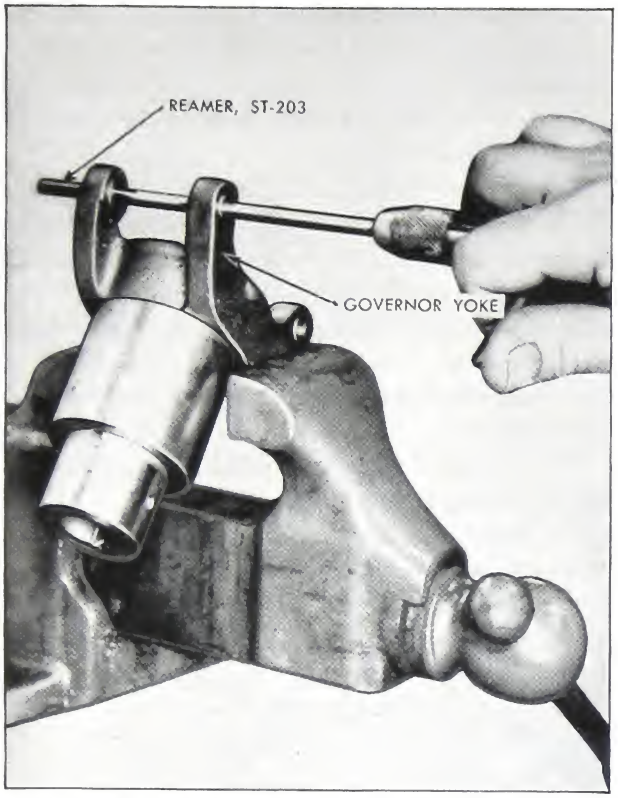


Fig. 5-119. Reaming governor weight pin bushings

Fig. 5-120. Compressing maximum speed spring

Ball Bearings: To replace ball bearings, S-16004, on the fuel pump drive gear of the less compressor fuel pump, remove the old worn bearing by prying with two opposing bars, while the gear is held in a vise with copper jaws. Fig. 5-121. Press on the new bearing.

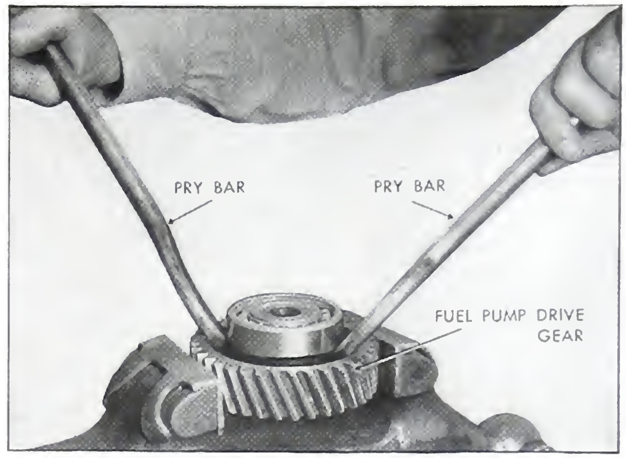


Fig. 5-121. Removing ball bearing from gear

GOVERNOR DRIVE HOUSING AND MAIN-SHAFT—Hydraulic: 1. If inspection has shown that the gear pump drive pin in the mainshaft needs replacement, drive in a new pin.

2. Use a gear pump drive shaft to line up the new drive pin and to hold it in place while peening the ends of the pin. Clean the shaft of any burrs or scored marks. See Fig. 5-117.

CAUTION: THIS PIN MUST FIT FREELY IN THE GEAR PUMP DRIVE SHAFT SLOT TO ASSURE PROPER ALIGNMENT AND PREVENT SCORING IN THE GEAR PUMP.

Fuel Cam: 1. Lubricate the shaft with heavy oil where the cam fits the shaft. Be sure the key is in place for the cam. Start the cams, with the distributor drive gear toward the gear pump end of the shaft, over the drive gear end of the shaft.

2. Line up the keyway and key and press the

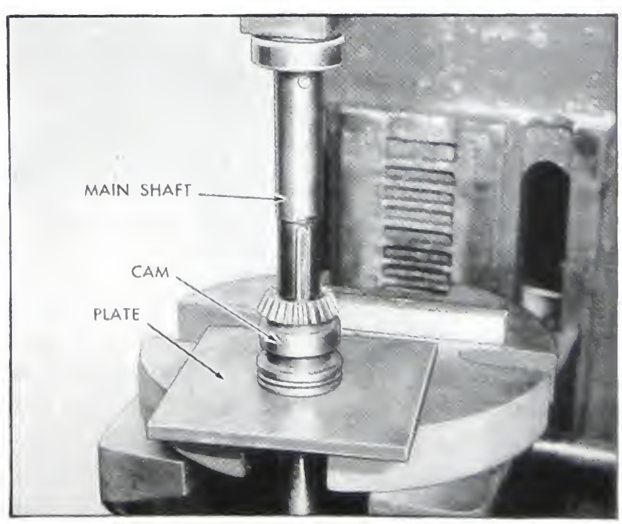


Fig. 5-122. Pressing cam on shaft

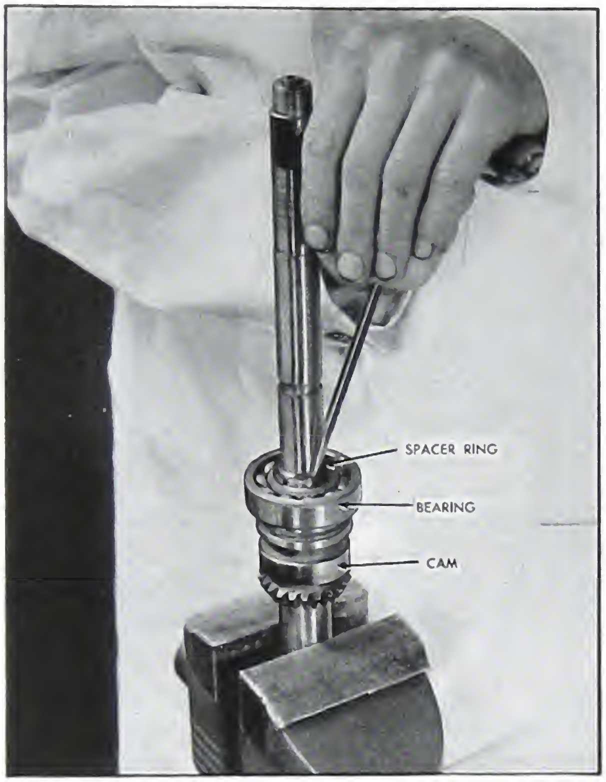


Fig. 5-123. Assembling lock ring

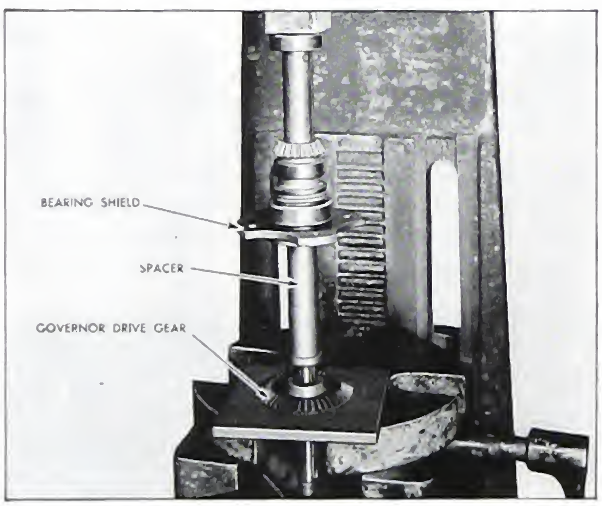


Fig. 5-124. Bearing shield, spacer and governor drive gear

shaft in to the cam and gear all the way to the stop. Figure 5-122.

Ball Bearings: 1. Press the large ball bearing on the shaft with the sealed side next to the fuel cam. Ball bearing spacer ring, No. 66071, is provided in 3 gauges, A, B or C. Select the thickest ring that will fit in the groove against the ball bearing.

2. Use expanding pliers to assemble the ring over the shaft to lock the ball bearing in place.

CAUTION: AVOID EXPANDING THE SPACER RING MORE THAN NECESSARY OR IT WILL BECOME PERMANENTLY DISTORTED.

3. Slip the spacer over the shaft into position with the long shoulder against the cam roller bearing.

Oil Seal: Replace the oil seal in the bearing shield with the sealing lip toward the governor drive housing and place the bearing shield on the drive shaft with the smooth side toward the cam roller.

Main Shaft: 1. Remove all burrs from the main shaft. Hold the shaft in a vise between copper jaws, with the keyways to the top, and replace the large and small keys. Lubricate the shaft.

2. Place the governor drive gear over the shaft with the keys and keyway indexed. The drive gear teeth must be toward the cam roller bearing. With the unit resting on the drive gear shoulder, press the shaft tight against the spacer from the gear pump end of the shaft. Fig. 5-124.

GOVERNOR DRIVE UNIT—Hydraulic: 1. Replace worn or defective parts and assemble as follows:

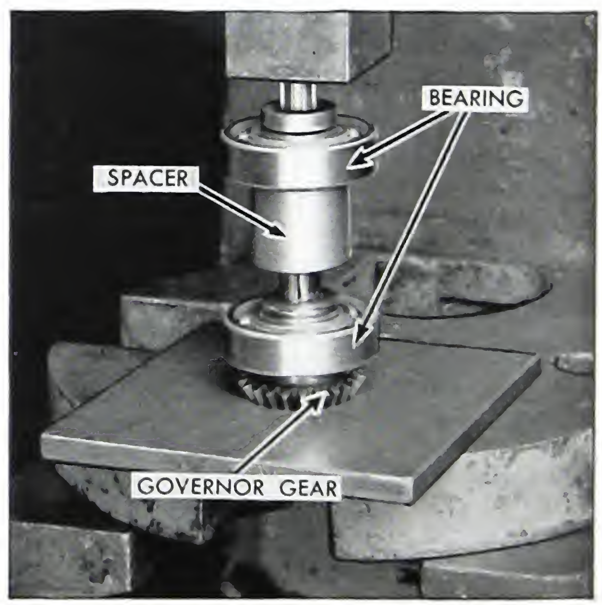


Fig. 5-125. Hydraulic governor drive unit assembly

2. Press the ball bearing on the gear to the shoulder.

3. Press the ball bearing on the spacer in position against the shoulder.

4. Press the spindle shaft through the spacer until the threaded end of the shaft is through the large end of the spacer and until the shoulder on the shaft comes to the stop in the spacer.

5. Place the Woodruff key in the shaft. Scribe the threaded end of the shaft in line with the Woodruff key. Lubricate the threaded end of the shaft. Start the pinion gear over the shaft and key by striking with a soft hammer.

6. Place the pinion gear in a plate with a beveled hole or protect the threaded shaft with a socket and, using a hard wood block on the splined end of the shaft, press the assembly together. Fig. 5-125.

7. Assemble the lock plate in place on the gear with the center punch mark located in the drilled hole in the gear. Tighten down the lock nut and bend the lock plate up on one side of the nut to lock in place.

HYDRAULIC GOVERNOR—WOODWARD SG: Most of the repair work consists of cleaning and polishing of parts. All pistons, plungers, valves and shafts should move freely without bind or catching. Do not lap in parts except as directed in following steps. Use No. 320 to No. 500 fine grit emery cloth for polishing.

Pilot Valve: Be extremely careful when polishing the pilot valve plunger land; broken corners on the land will ruin this part. Leave corners sharp.

Case: If ground case surface is grooved or worn

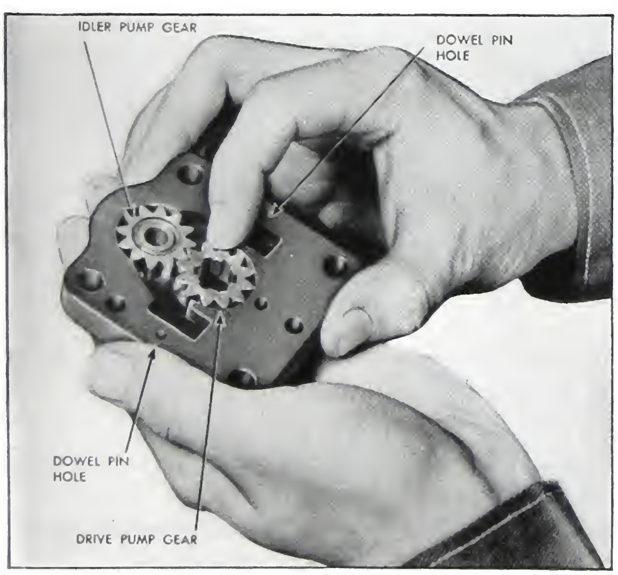


Fig. 5-126. Testing pump gears

from rotation of the pump gears or scratched from mishandling (See Fig. 5-60), it may be surface ground. 1/32" stock may be removed, if necessary, to clean up. If surface grinder is not available, lap the surface smooth on a flat plate.

Base: If ground flat surface of base is warped, nicked, or deeply scratched, it may be lapped smooth on a flat plate. Do not remove more stock than necessary to clean up. If depth of gear pockets is reduced, the gears will bind and it will be necessary to lap the faces of the gears to free.

Ballhead: If ballarm pins are cottered, remove cotters to disassemble. If ballarm pins are riveted, grind off one end to disassemble and use new pins to reassemble.

Limit Pin: This pin must be tight in speed adjusting lever. Stake tight, if loose.

Pump Gears: The pump gears should be tested for free rotation as shown in Fig. 5-126. If gears turn roughly, inspect for nicks or wear of the gear teeth and interference at internal corners of bores for gears.

ASSEMBLY—*Base and Case:* 1. Drive dowel pins out of base.

2. Place pump gears as shown in Fig. 5-126.

3. Coat surface of base with oil. Do not use shellac.

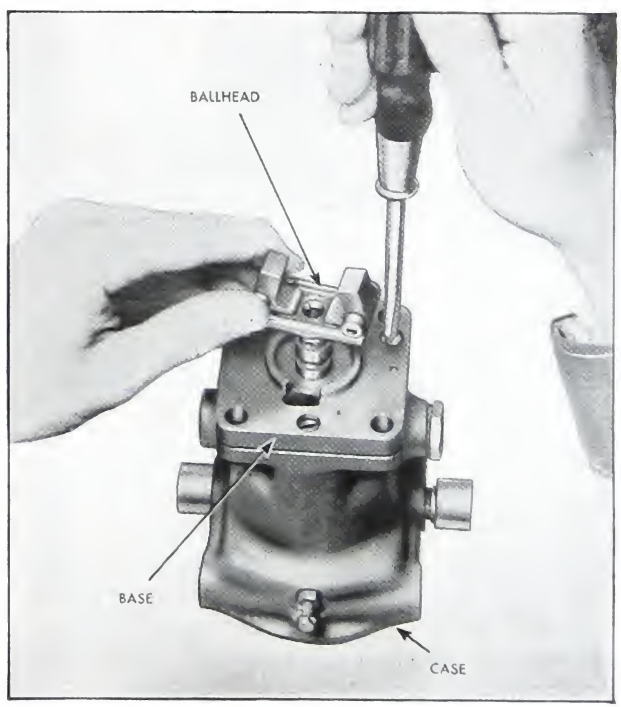


Fig. 5-127. Assembling base to case

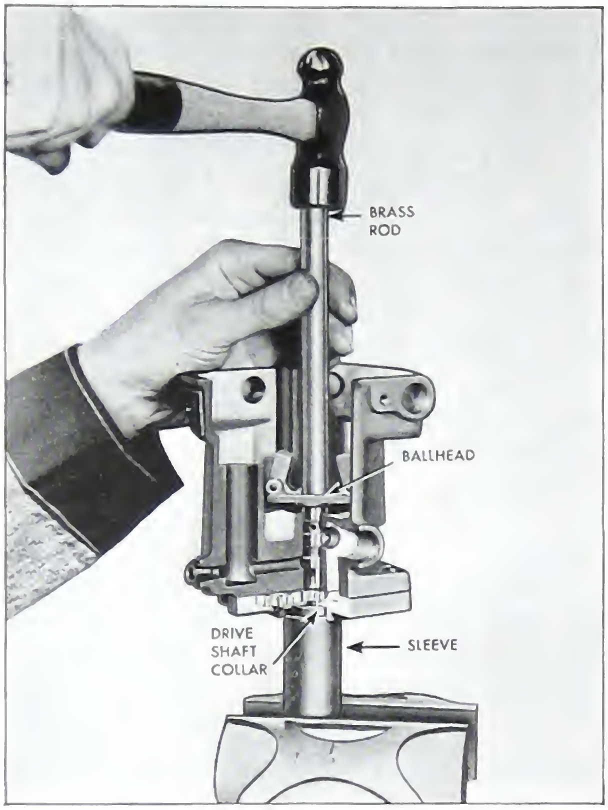


Fig. 5-128. Driving collar on drive shaft

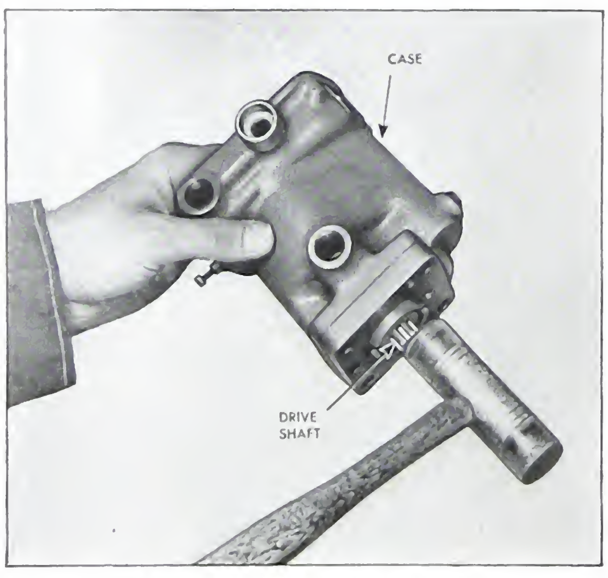


Fig. 5-129. Free drive shaft "a"

4. Place gasket, if used, on base, spacing gasket evenly around edge of bores for gears. If the old gasket is damaged or compressed to less than .003", use a new .005" gasket. Do not tap out a gasket with a hammer; it will round the sharp

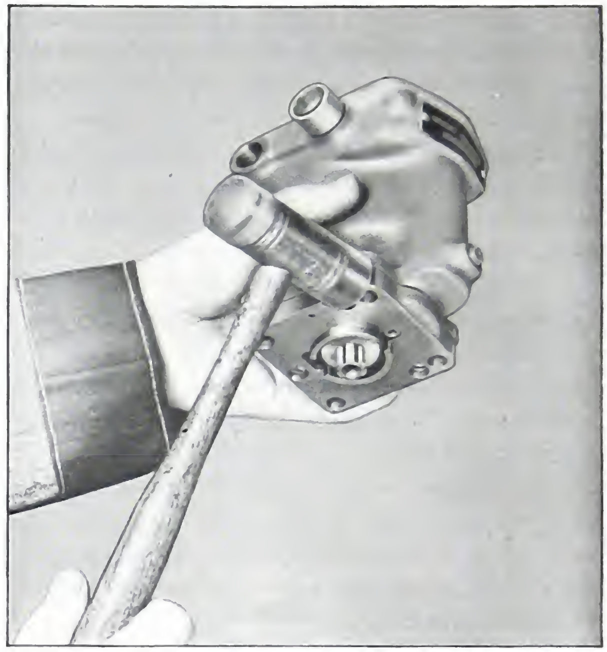


Fig. 5-130. Free drive shaft "b"

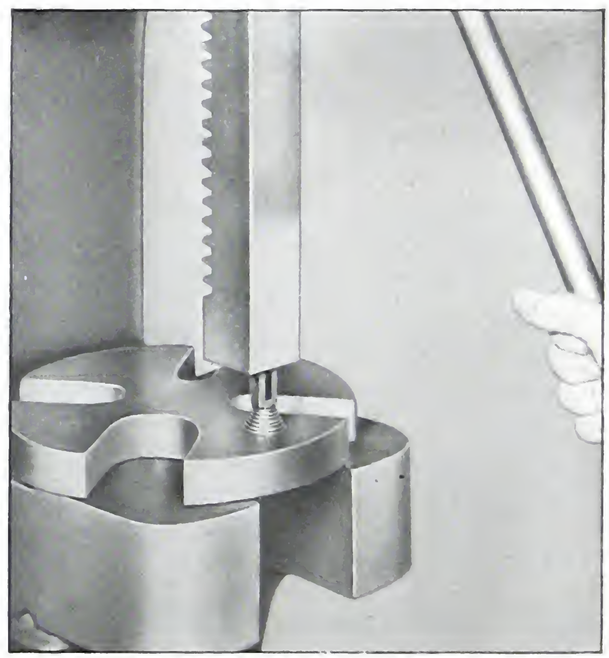


Fig. 5-131. Speeder spring and fork

edge at the bores for the pump gears resulting in excessive pump leakage.

5. Place case on base, invert and place ballhead through base and case, as shown in Fig. 5-127.

6. Insert three base screws and turn ballhead to obtain free rotation while tightening.

7. Insert dowel pins and set down below base

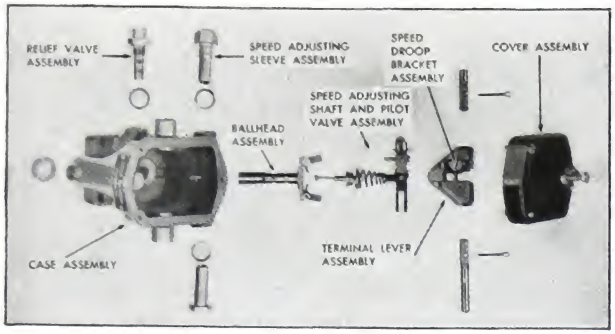


Fig. 5-132. Governor parts

surface approximately 1/16". Use. 3/32" drift or rod.

8. Clamp sleeve in vise, place ballhead in governor, place drive shaft collar on drive shaft, and drive collar onto drive shaft with 7/16" brass rod as shown in Fig. 5-128.

9. Tap end of drive shaft tightly with plastic hammer until ballhead and shaft turns freely with a minimum of end play. See Fig. 5-129.

10. Turn drive shaft with finger. If it binds, loosen screws and free by striking at corners of base, as shown in Fig. 5-130.

11. To assemble the speeder spring and spring fork, press them together in an arbor press as shown in Fig. 5-131.

12. Assemble the pilot valve plunger, speeder spring and spring seat in the valve as shown in Fig. 5-132.

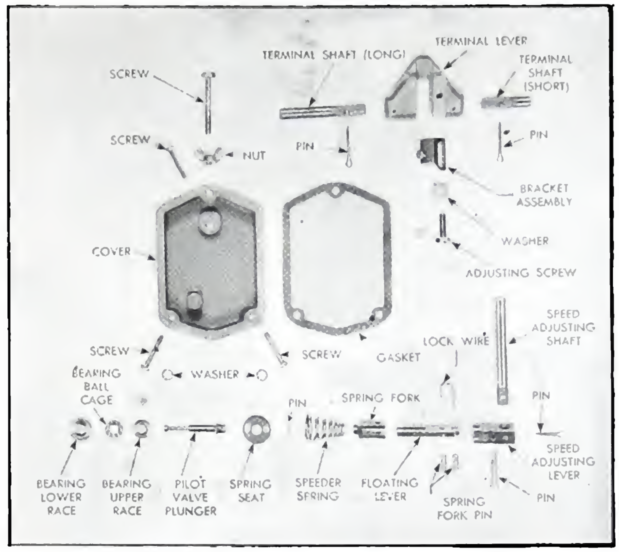


Fig. 5-133. Governor parts

13. If necessary to press terminal sleeves into case, insert a support plate of exactly correct width between inside bosses of case and press the sleeves into the case with an arbor press.

14. Put a drop of oil in the relief valve when reassembling.

15. Lubricate all working parts with No. 10 lubricating oil.

ASSEMBLY AND ADJUSTMENTS

FUEL PUMP MAIN HOUSING: 1. The fuel pump main housing and governor housing should be painted inside with a red oxide sealer and thoroughly dried before assembly.

2. Test shafts individually in newly reamed bushings, Fig. 5-134. Remove all burrs or sharp edges with a bearing scraper, if this was not done during the rebuilding process.

3. Install the governor control shaft through the bushing in the main housing (hydraulic-type only). Use a new "o" ring on the shaft of late pumps.

4. Lubricate the eccentric shaft and install in housing. Place pilot of ST-440 over shaft and slide the 70536 seal over pilot and press 1/16" deep with mandrel of ST-440.

5. Install the governor lever—assembled with the vertical lever link and the governor lever link —to the eccentric shaft.

6. Assemble the collar over the governor lever and insert a new cotter pin. Make sure that there is no more than .002" thrust on the governor lever when the assembly is completed. Fig. 5-135.

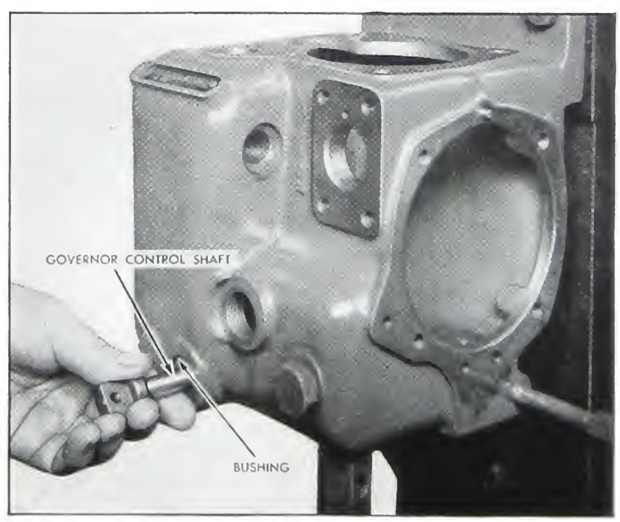


Fig. 5-134. Testing for wear of shaft bushing

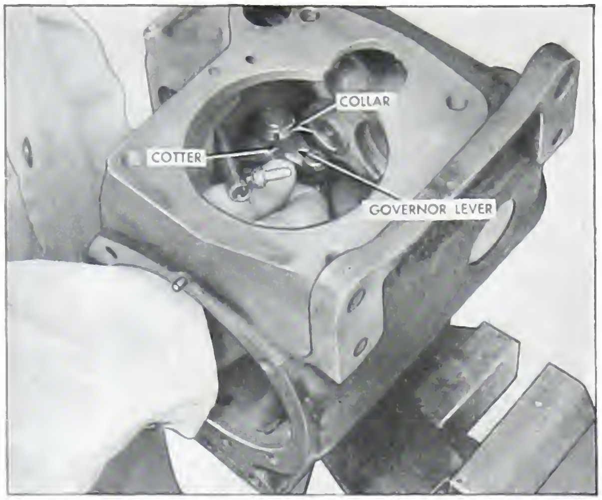


Fig. 5-135. Assembling governor lever collar and pin

7. Install the cam rocker lever assembly in the housing.

8. Assemble the gear pressure pump assembly to the main housing to make the test for the cam rocker lever assembly. Be sure to use the proper gasket between the main housing and the gear pump housing. Bolt a No. 1 gear pump housing or the gear pump, in position to the body. Fig. 5-136.

9. Check the cam rocker lever to see that it rocks freely (Fig. 5-137) and that it has at least .006″ end thrust. If the lever does not rock freely, it will affect the fuel pump delivery.

10. Remove the No. 1 gear pump housing, or gear pump, from the main housing.

11. Place the vertical lever assembly in posi-

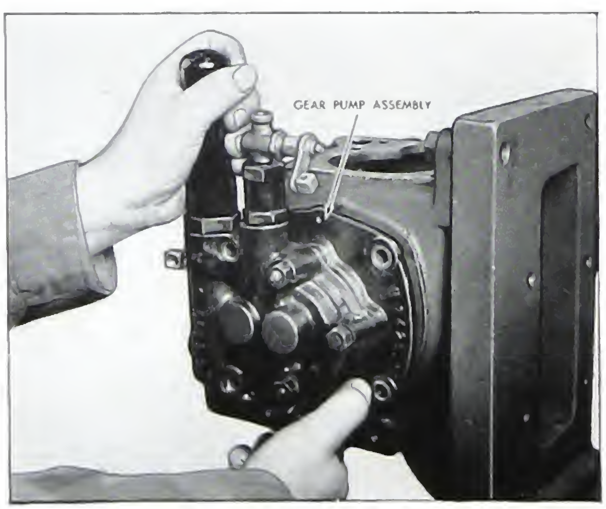


Fig. 5-136. Test for cam rocker lever

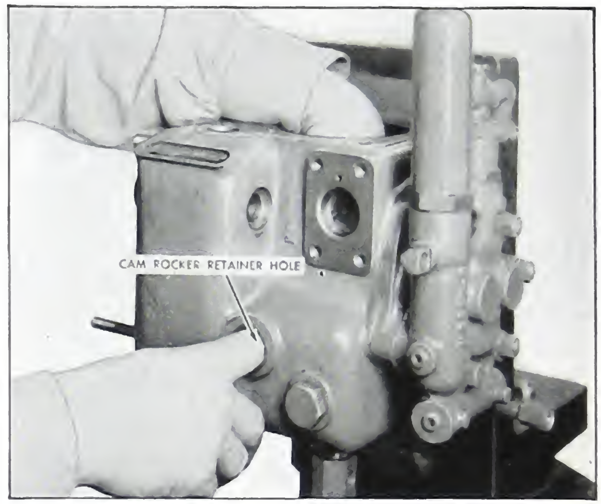


Fig. 5-137. Checking cam rocker lever action

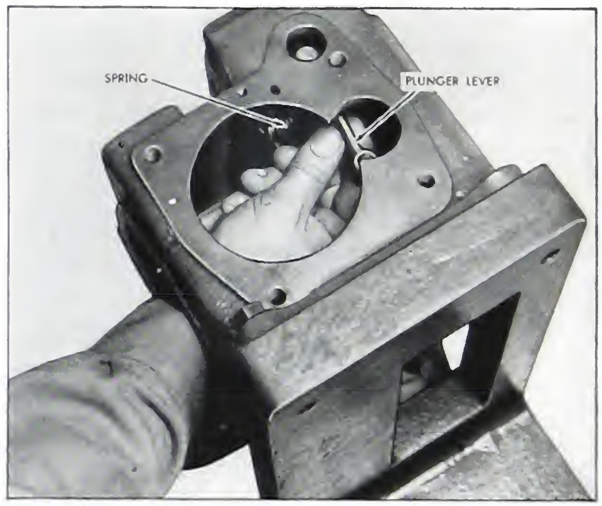


Fig. 5-138. Installing vertical lever assembly

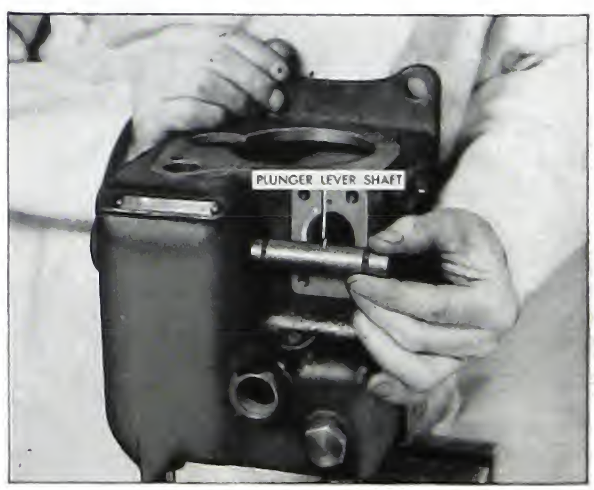


Fig. 5-139. Assembling plunger lever shaft

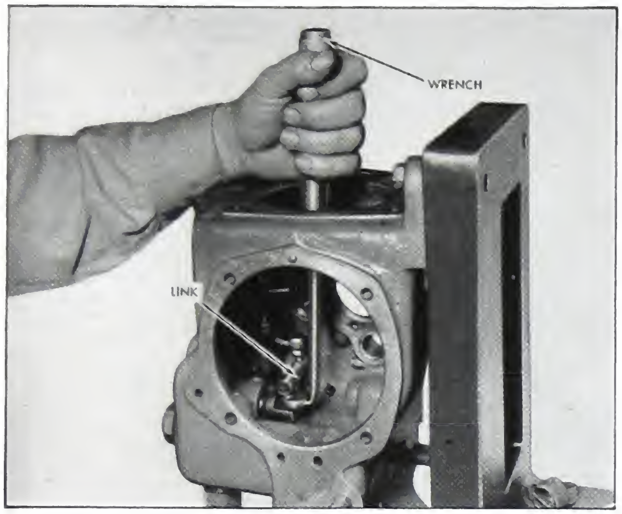


Fig. 5-140. Assembling control shaft link (Hydraulic)

tion in the housing. Fig. 5-138.

12. Insert the plunger lever shaft—with the oil grooves placed to match the oil holes in the bushing—in the housing and through the plunger lever. Fig. 5-139.

Hydraulic: 13. Assemble the control shaft link, with a new lockwasher, to the governor control shaft. (Fig. 5-140).

Mechanical and Hydraulic: 14. Assemble the vertical lever link, with a new lockwasher, to the vertical lever.

15. It is necessary that the vertical lever and roller be spaced in the center of the cam rocker

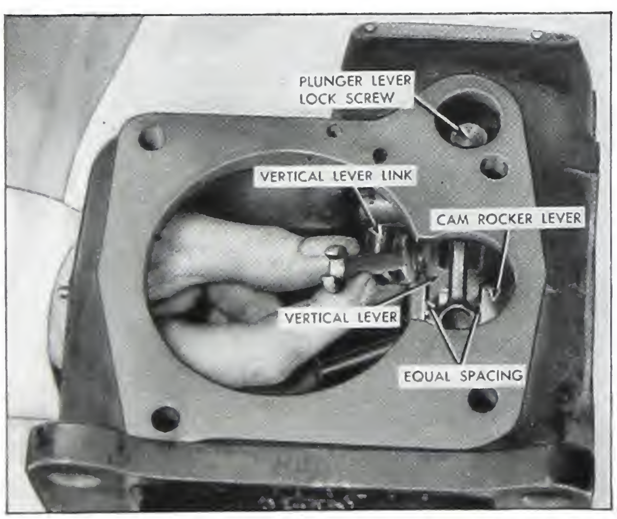


Fig. 5-141. Assembling vertical lever link

lever race for the proper working position. To space the vertical lever, it may be necessary to shift the plunger lever shaft bushings. End play of cam rocker lever must be considered during this spacing.

CAUTION: BE SURE THE NEEDLE BEARINGS HAVE NOT BEEN SHIFTED.

16. Tighten the lock screw with a socket wrench. Test the action of the plunger lever. It should have a side thrust of at least .001″.

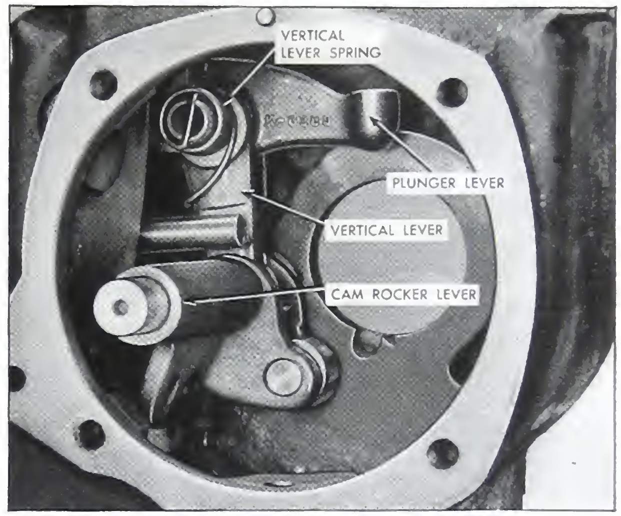


Fig. 5-142. Vertical lever spring in position

17. Insert new expansion plugs at each end of the plunger lever shaft. Use a welch plug set from ST-190 to wedge the plugs in place. Use Permatex on the edges of the expansion plugs.

18. Check the position of the vertical lever and the roller in the cam rocker lever race to see that it has not shifted while inserting the expansion plugs. Check to see that the plunger lever and vertical lever work freely.

19. Place the vertical lever spring in position. Fig. 5-142.

MAIN SHAFT AND GOVERNOR ASSEMBLY —Mechanical:

1. Assemble a No. 1 gear pump housing used only for this purpose to the fuel pump main housing.

2. Assemble the yoke tube to the mainshaft and secure with snap ring. Yoke tube should have a minimum of .004″ end clearance.

3. Slip the mainshaft with its assembled ball bearings, fuel cam, yoke tube and snap rings into the main housing in position. The fuel pump cam rocker lever must be pushed down so the roller will clear the gear as the shaft is being installed.

4. Assemble the ball bearing shield gasket and shield over the shaft and secure with cap screws.

5. Lubricate the governor yoke tube and governor control rod bushing with clean oil. Assemble the governor yoke sleeve and assembled governor control rod, collar, maximum speed spring and spring sleeve over the main shaft and yoke tube. The governor yoke sleeve and control rod must be a free sliding fit on the shaft and in the bushing or erratic governor action will result. If the control rod bushing has been line reamed with fixture, ST-109, and rod and collar replaced as an assembly there should be no misalignment. See Fig. 5-143.

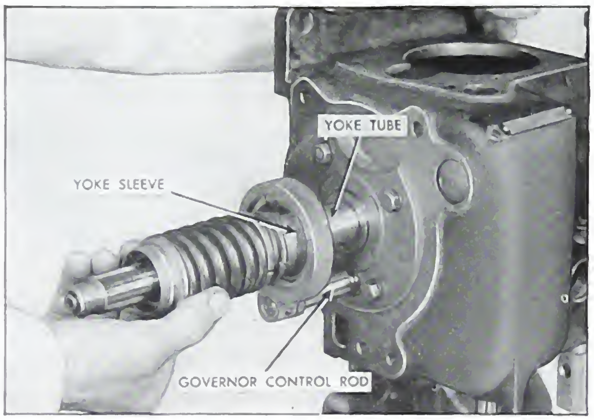


Fig. 5-143. Checking governor sleeves and control rod

6. Loosen and remove the cap screws from the bearing shield and pull the main shaft assembly from the main housing.

7. After removing any burrs, assemble the key for the governor yoke on the main shaft. Put the idling spring and increased torque spring, or spacers, as called for in current parts books, on the mainshaft. Grease the mainshaft and press the yoke on the shaft over the key all the way to the stop as shown in Fig. 5-144.

8. Reinstall the governor and main shaft assembly to the main housing using the proper bearing shield gasket. Tighten the cap screws with lock washers to secure the bearing shield to the main housing.

9. Remove the "dummy" No. 1 gear pump housing from the main housing and assemble the governor link with lockwasher to the governor control rod as shown in Fig. 5-145.

10. Reinstall the "dummy" No. 1 gear housing to the fuel pump main housing.

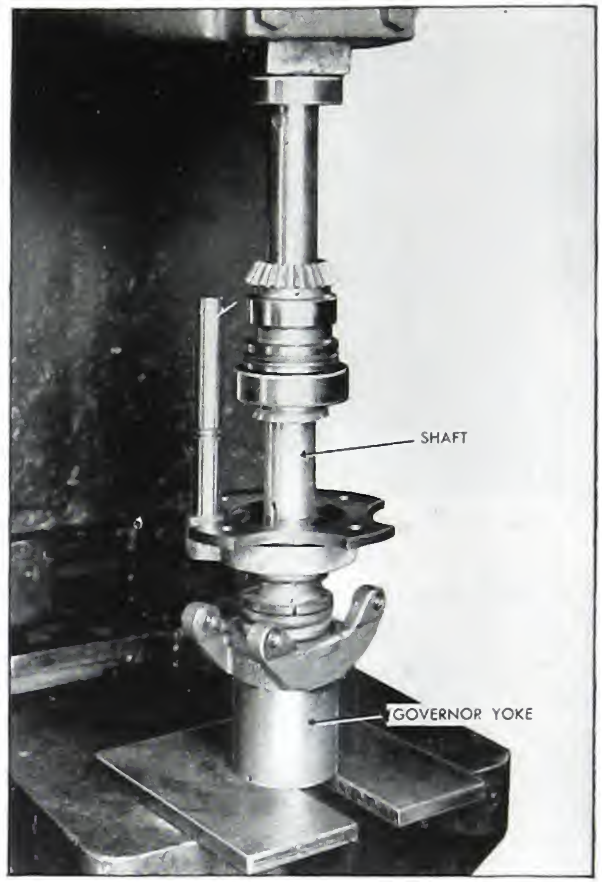


Fig. 5-144. Pressing yoke on shaft

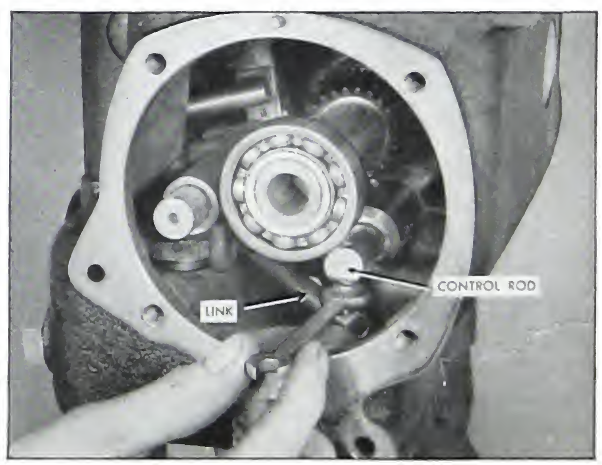


Fig. 5-145. Assembling governor link

11. The governor weights should have 1/16 inch free motion before engaging the idling spring. Fig. 5-146.

12. While holding down on the top end of the eccentric shaft, assemble the control lever to the eccentric shaft in stop position. (Fig. 5-147).

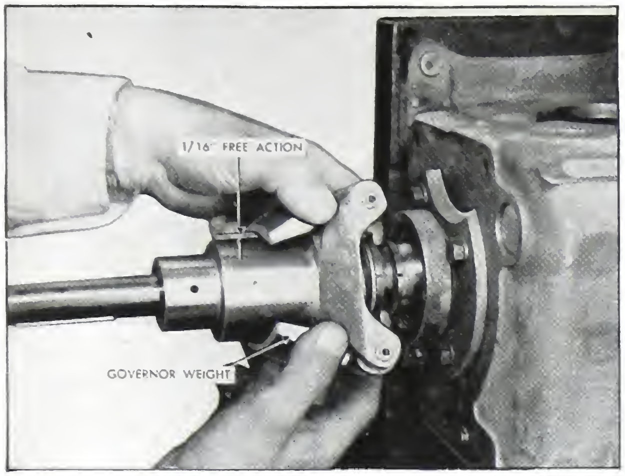


Fig. 5-146. Testing free action of weights

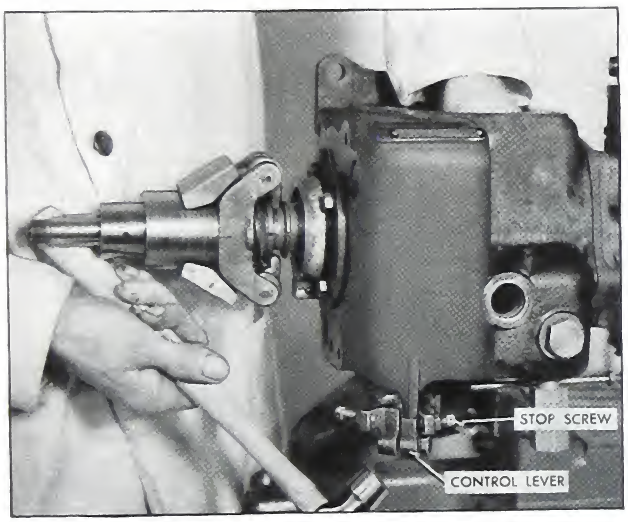


Fig. 5-147. Assembling fuel control lever

13. Turn the stop screw in to the stop on housing, and lock in place with jam nut.

14. If a new control lever or eccentric has been installed, it will be necessary to drill a new pin hole in lever and shaft.

15. For pumps that have a stop sleeve on the fuel pump cam rocker lever, turn the stop screw in shut-off direction just enough to keep the vertical lever roller from touching stop sleeve. Further adjustment of stop screw must be made on the fuel pump test stand.

16. Assemble the governor housing with gasket to the fuel pump housing and secure with cap screws and lock washers.

17. Remove the No. 1 gear pump housing used for test purposes.

18. Assemble the key for the fuel pump drive gear, or spider coupling shaft, on the shaft and

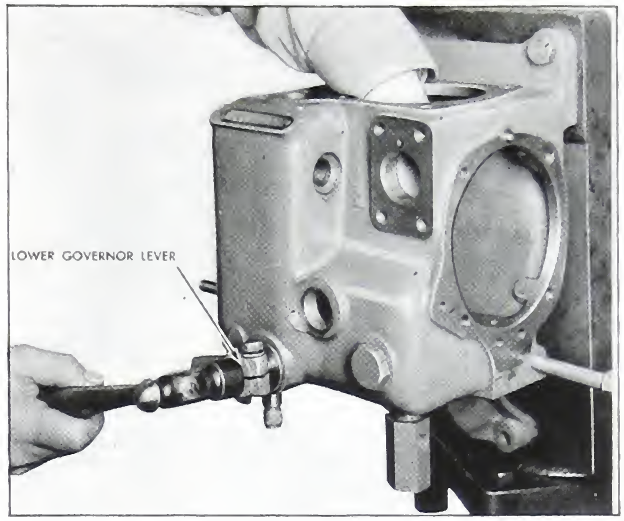


Fig. 5-148. Assembling lower governor lever

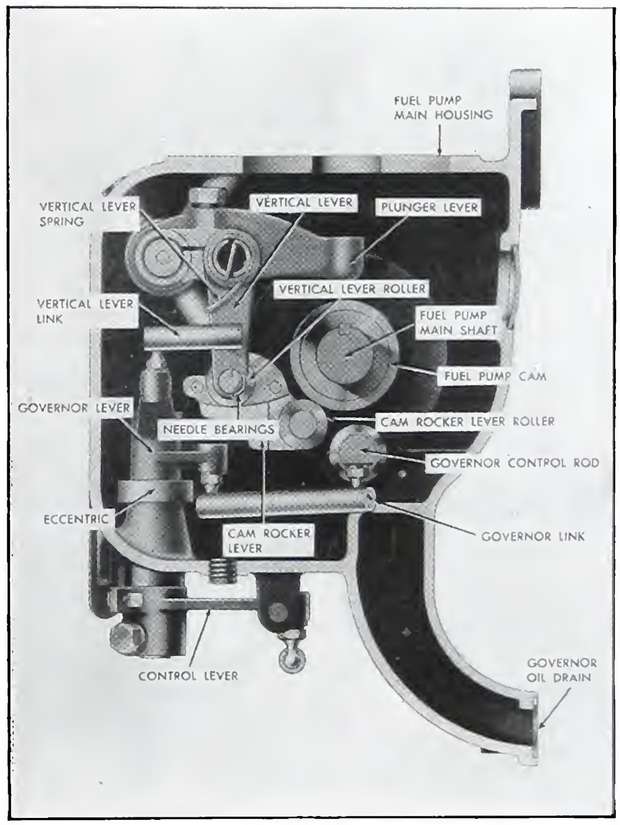


Fig. 5-149. Cross section of standard fuel pump main housing

press the gear (or spider) on the shaft in an arbor press as shown in Fig. 5-156. Support ball bearing end on shaft on plate of the press.

MAIN SHAFT AND GOVERNOR ADAPTER—Hydraulic: 1. Put the spacer and Woodruff key on the governor control shaft. While supporting

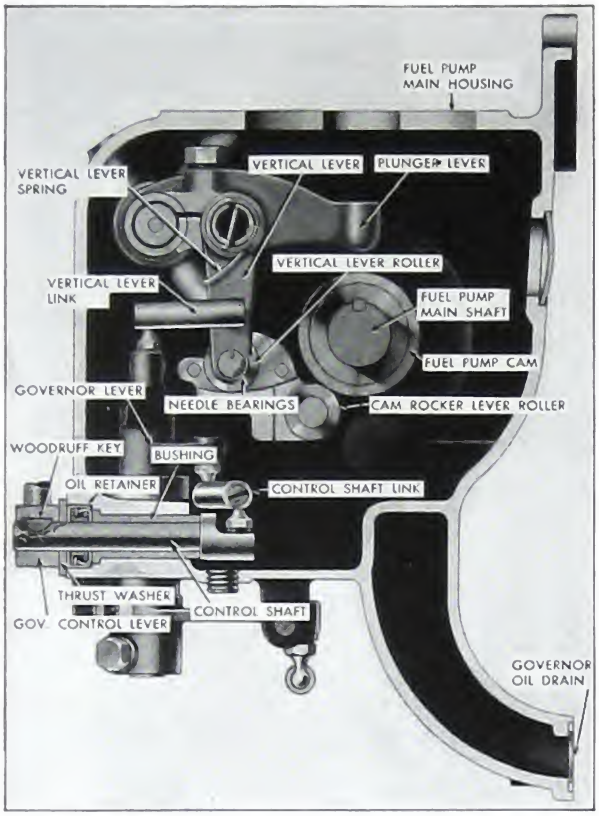


Fig. 5-150. Cross section of hydraulic type fuel pump main housing

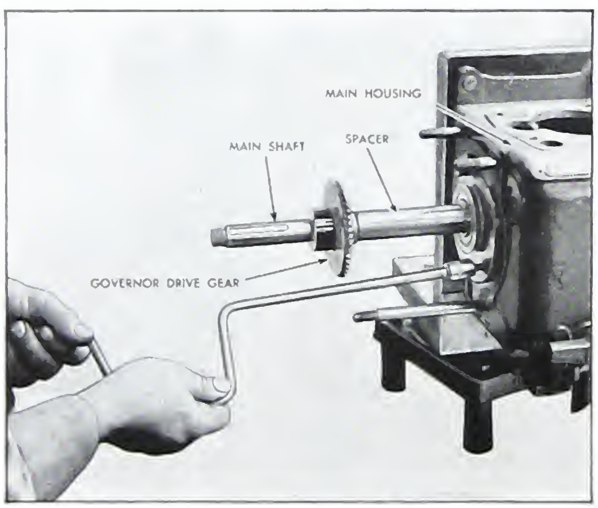


Fig. 5-151. Main shaft assembly

the governor control shaft from inside the main housing, assemble the lower governor lever over the key to the control shaft. Fig. 5-151.

2. Secure the gear pump assembly in place on the main housing with capscrews and lock-washers.

3. Put a new .003" bearing shield gasket in

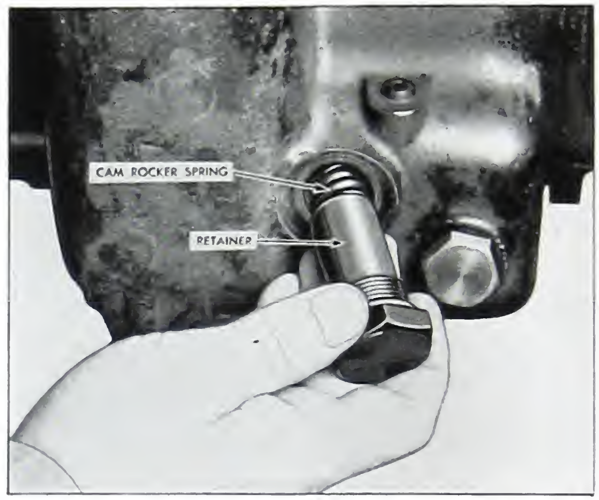


Fig. 5-152. Cam rocker lever spring and retainer

place and insert the main shaft assembly in the main housing, lining up the drive pin in the main shaft with the gear pump shaft slot.

4. Secure the retainer plate to the main housing with capscrews and lockwashers. The two cut-out portions of the plate must be to the top and back.

5. Assemble the cam rocker lever spring and retainer in position in the main housing. Fig. 5-152.

6. To install the fuel control lever, turn in the eccentric shaft in direction of arrow "B" to stop pin. This is the "off" position for the hand control lever. Fig. 5-153.

7. Pull the lower governor lever in direction of arrow "A" to stop pin. This is the full fuel position for the governor control lever.

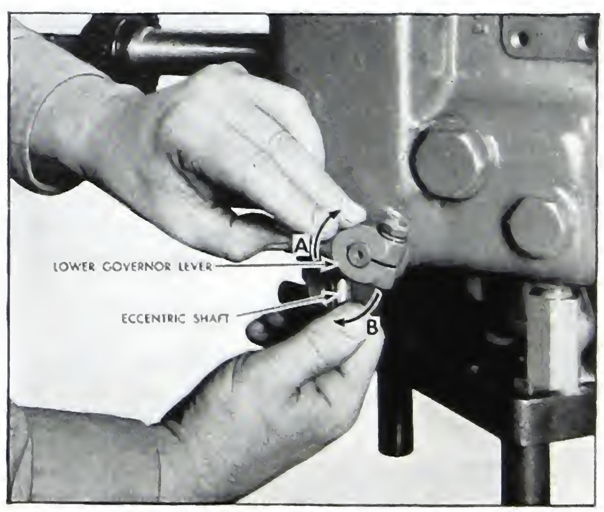


Fig. 5-153. Fuel control lever

8. Hold the eccentric shaft down in position with a screwdriver and press against the eccentric shaft from inside the main housing. With the levers in this position, install the fuel control lever in the "OFF" position. Fig. 5-154.

Levers must be assembled in this position to insure full governor control and prevent linkage strain.

The fuel adjusting screw should be adjusted so that it contacts the boss on the housing at the same time or just before the vertical lever roller contacts the stop sleeve.

9. If the eccentric shaft has not been changed, the drilled holes in the eccentric shaft and fuel control lever will be properly indexed for the rivet pin. Insert the rivet pin and peen in place. If a new eccentric shaft has been installed, the clamp screw of the control lever must be tightened while the levers are held in the position described above. Drill through the control shaft in line with the holes in the lever and install a new rivet. Peen the rivet in place.

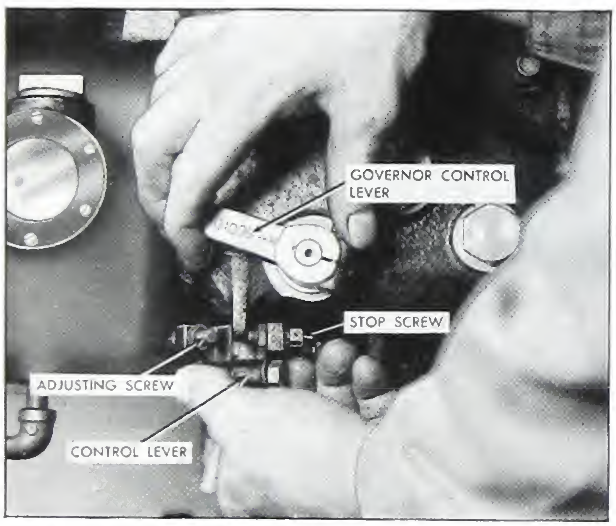


Fig. 5-154. Assembling constant speed fuel pump control lever

10. Replace the oil seal in the drive housing of compressor type or hydraulic governor type pumps. Drive out the old seal from the inside. Use a mandrel and press in the new seal, with the sealing lip toward the inside of the housing, 1/32" below the face of the shoulder. Fig. 5-155.

CAUTION: AVOID TURNING THE SEAL WHILE ASSEMBLING THE GOVERNOR DRIVE HOUSING OVER THE MAIN SHAFT.

11. Use a new gasket and assemble the gover-

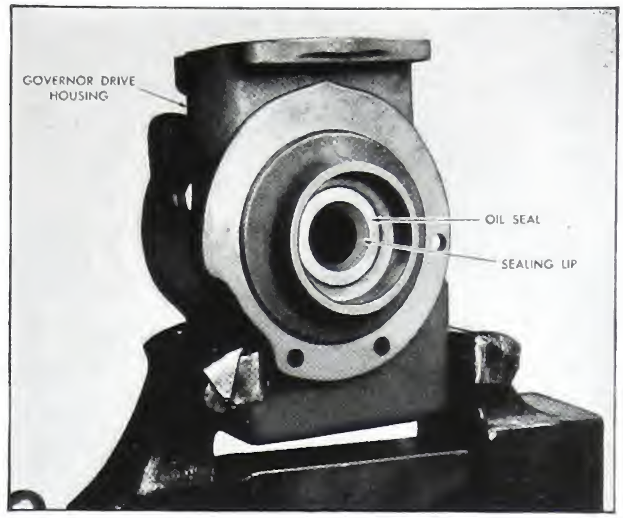


Fig. 5-155. Oil seal in governor drive housing

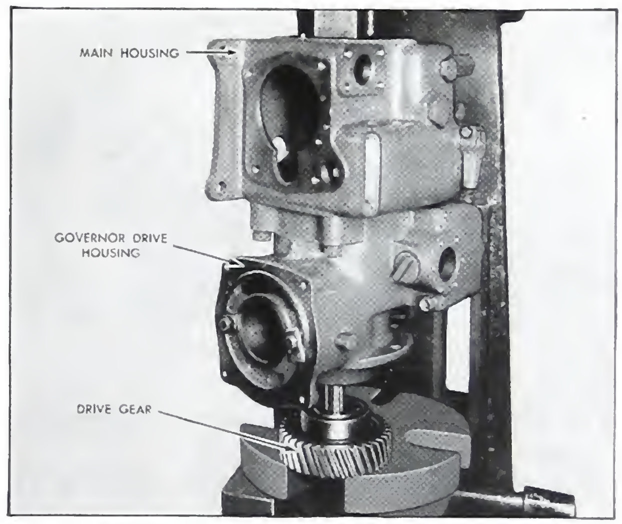


Fig. 5-156. Pressing on fuel pump drive gear

nor drive housing to the main housing over the studs and secure with lockwashers and capscrews.

12. Test the shaft to see that it turns freely. Lubricate the end of the drive shaft with heavy lubricating oil. Start the drive gear on the shaft, over the key, by striking lightly with a soft hammer.

13. Remove the gear pump assembly from the housing.

14. With the drive gear down, place the assembly in an arbor press. Put a flat plate over end of shaft and ball bearing. Press against the plate to press the drive gear on the shaft to the stop. Fig. 5-156.

CAUTION: USE CARE TO PRESS ON STRAIGHT TO AVOID SCORING THE SHAFT. SHORT STROKES OF THE

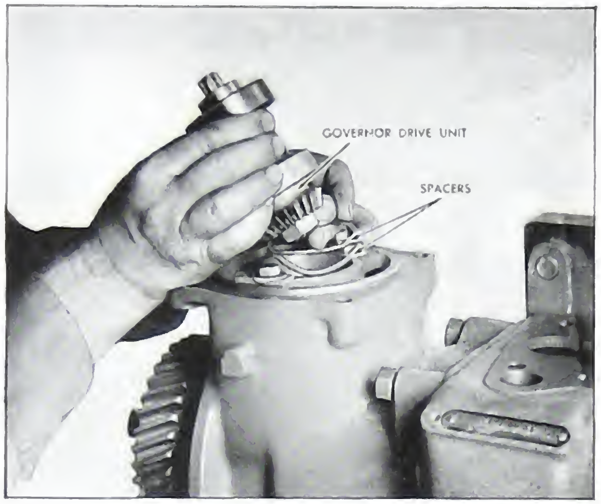


Fig. 5-157. Installing governor drive

PRESS HANDLE WILL LESSEN THE CHANCES OF SCORING.

15. Replace the gear pump to the main housing, using a new gasket, and secure with lockwashers and capscrews. Tighten to 30 foot pounds with a torque wrench. Test to see that the assembly turns freely.

GOVERNOR DRIVE UNIT—Hydraulic: 1. The gear back lash between the bevel gears on the governor drive unit and main shaft should be .002 to .004. If necessary, install enough spacers to provide .002 to .004 clearance as gears are turned a full revolution. Fig. 5-157.

2. Install the drive unit assembly in place on the adapter housing. Put the splined coupling on the end of the splined shaft and drive the unit

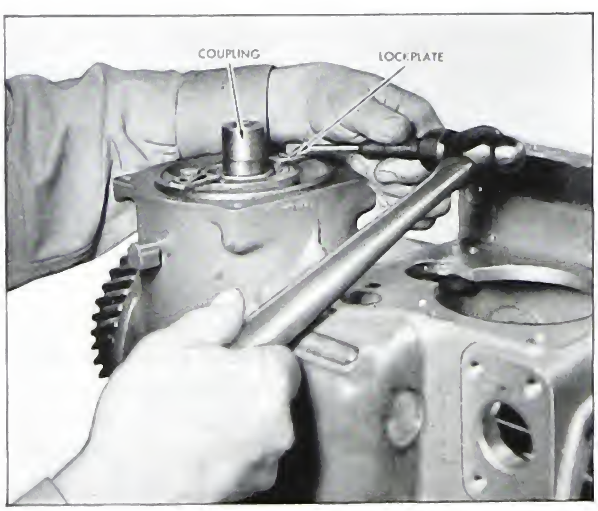


Fig. 5-158. Lock plates

into place with a rawhide hammer, while shifting the main drive gear to engage the pinion driving gears.

3. There must be .002 to .004 gear back lash. Test by rocking the fuel pump drive gear while holding the splined drive shaft of the governor drive unit. If there is no back lash, it will be necessary to add another spacer under the drive unit. Turn up the lock plates with a flat end punch to lock in place.

4. Turn the lock plates to lock against the ball bearing retainer and tighten the capscrews. Fig. 5-158.

5. Using a new gasket, assmble the adapter plate with the oil hole toward the gear pump end and secure with lockwashers and capscrews. The spring clip goes under the left front capscrew.

HYDRAULIC GOVERNOR: 1. With the name plate toward the gear end of the pump, place the governor on the drive unit while rotating the main shaft to engage the splined shafts and coupling. Secure with lockwashers and nuts.

2. Assemble the terminal lever to the terminal lever shaft. Do not tighten the capscrew at this time.

3. Attach the control link to the governor control lever and terminal lever, using new lockwashers.

GEAR PRESSURE PUMP—Mechanical and Hydraulic: 1. Assemble the gear pressure pump to

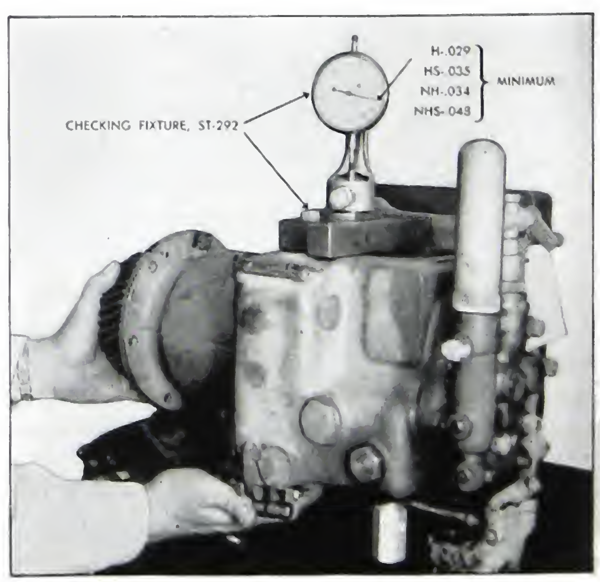


Fig. 5-159. Metering plunger travel

the main housing using the proper gasket between gear pump and housing. Tighten capscrews to 30 foot pounds with a torque wrench. Turn shaft as needed to engage slot of gear pump drive shaft over the pin in the mainshaft. Turn the mainshaft to see that it does not bind.

2. At any time a gear pump is assembled to the fuel pump, make sure that the cam rocker lever has a minimum of .006 end clearance and that the vertical lever roller is spaced in the cam rocker lever race, so it has clearance after allowing for end clearance of cam rocker lever.

3. Install a fixture, ST-292, with metering pump, spring and dial indicator attached as shown in Fig. 5-159, to the main housing. With fuel control lever clamped in full fuel position,

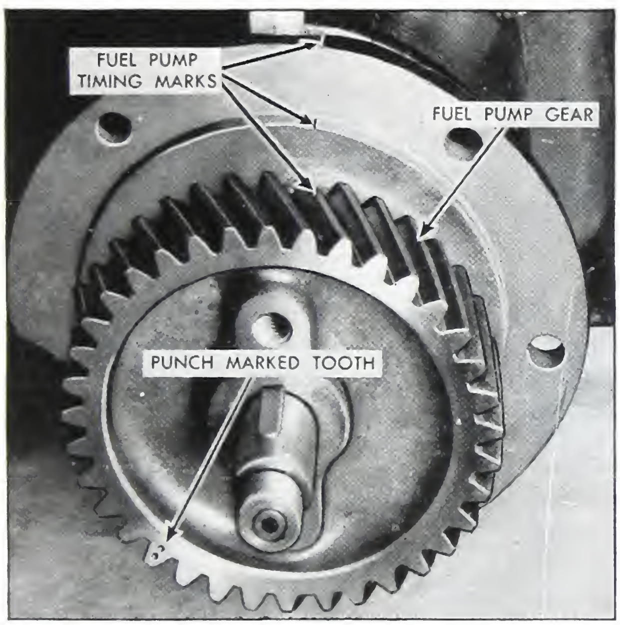


Fig. 5-160. Timing marks on fuel pump gear and housing

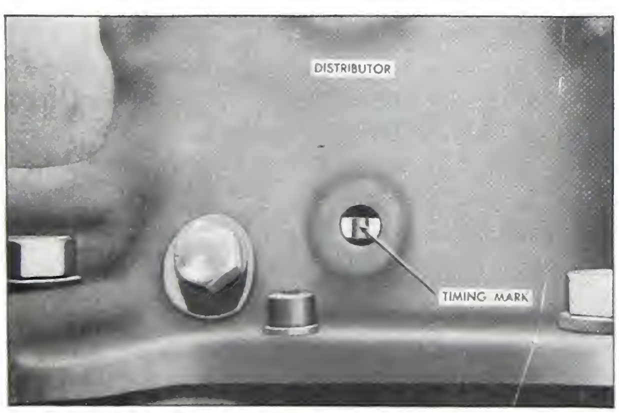


Fig. 5-161. Distributor collar timing mark

the minimum travel of metering plunger should be as follows for various pumps:

H (BM-1) 029	NH (BM-1) 034
HS (BM-4) 035	NHS (BM-1) ...048

4. With fuel control lever in shut-off position, the indicator of ST-292 should read "0" as the fuel pump mainshaft is turned.

DISTRIBUTOR: 1. Set the timing mark on the drive gear or spider to match the timing mark on the governor drive housing. Fig. 5-160.

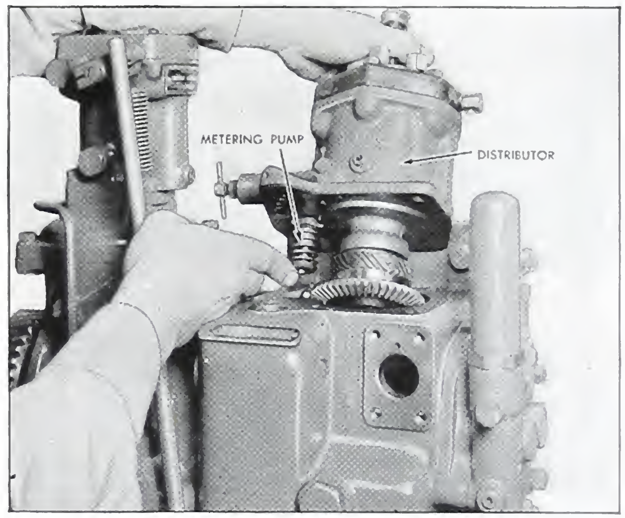


Fig. 5-162. Distributor assembly

2. Set the timing mark on the distributor disc drive collar to line up with the inspection hole. (Fig. 5-161).

3. Install the metering plunger and spring to the metering pump barrel. Put the plunger link in the socket of the plunger lever.

4. Place a gasket of the proper thickness on top of the fuel pump main housing. Assemble the distributor housing to the main housing while carefully guiding the metering plunger link into position in the plunger. Mesh the gears by rocking the drive shaft. Fig. 5-162.

5. Install and tighten down the four capscrews and one Allen screw to secure the distributor in place on the main housing.

6. The thickness of the gasket between the distributor housing and the main housing determines the gear lash of the distributor drive gear. The distributor drive gear lash should be .002 to .004. This can be checked by rocking the main shaft gear by hand. Turn the distributor gear one complete rotation, checking at various positions.

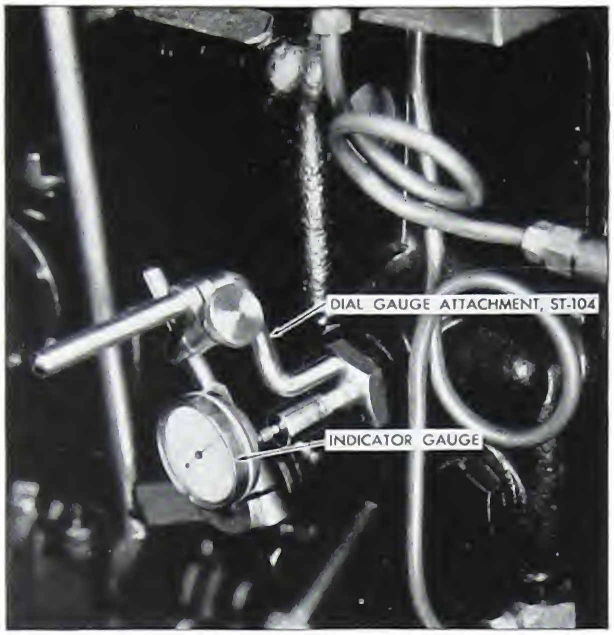


Fig. 5-163. Gauging fuel cam lift

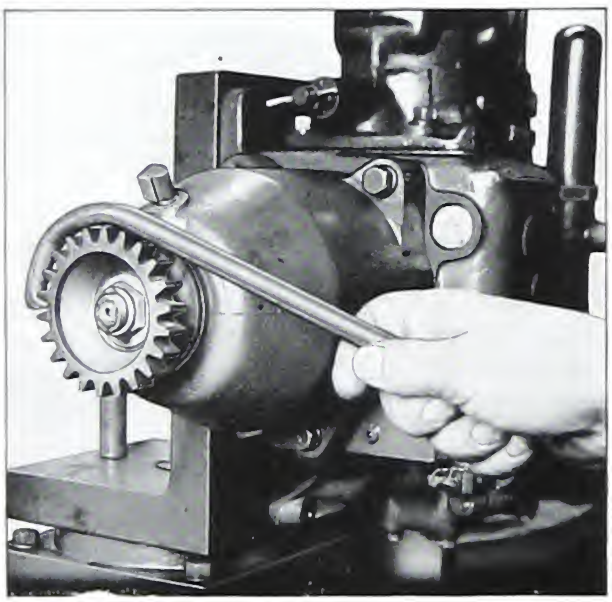


Fig. 5-164. Turning fuel pump shaft

7. Install dial indicator gauge and attachment, ST-356, in fuel pump main housing in place of the cam rocker lever spring and retainer, Fig. 5-163.

8. Turn the fuel pump main shaft in its operating direction until the timing marks line up for assembly position, i.e., until notch on distributor collar shows through peep hole in the distributor housing. At this point the dial indicator gauge should register the low point. Set gauge at "0". ST-198 is a special spanner wrench that can be used to engage in a tooth of the fuel pump coupling spider to turn the main shaft. Fig. 5-164.

9. Turn the main shaft until the indicator gauge shows that the cam rocker lever roller is in contact with the highest point of the fuel cam lobe. For the model H pump this will be .032.

10. Variations in total travel from lobe to lobe will permit a variation in fuel delivery of approximately 1 cc for each .001 variation of dial indicator reading. This variation should in no case exceed 2 cc.

11. Remove the timing fixture, ST-356, and install the cam rocker lever spring and retainer in the fuel pump housing.

12. Install the fuel supply tube from the gear pump to distributor.

OVERSPEED STOP: 1. Using the proper gasket, install the assembly to the fuel pump, being careful to mesh the gear with the drive gear on the distributor. Fig. 5-165.

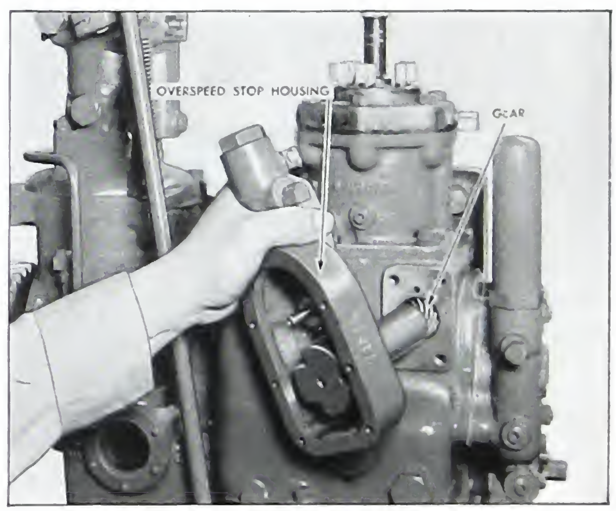


Fig. 5-165. Installing overspeed stop

2. Secure in place with four fillister head screws and lock washers. Tighten evenly and securely with a heavy duty screwdriver and wrench. Fig. 5-166.

3. Check the shaft for gear lash and end thrust. There should be .003 gear lash and .002 end thrust.

CAUTION: WHEN CHECKING THE GEAR LASH, HOLD THE SHAFT TIGHT AGAINST THE OVERSPEED STOP BODY. IF THIS IS NOT DONE, THE MOTION FELT MAY BE END PLAY AND NOT GEAR LASH.

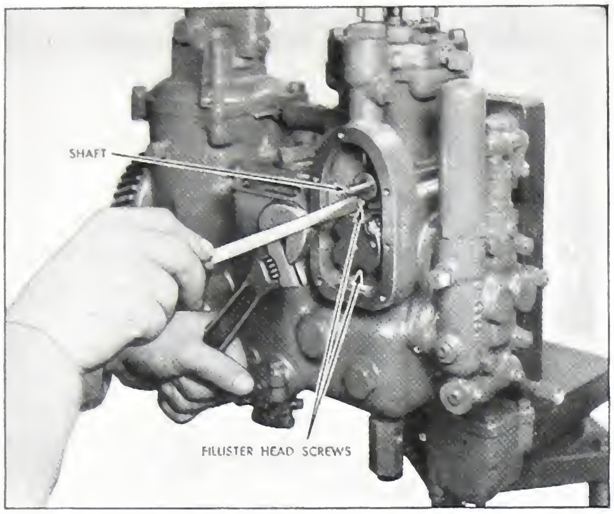


Fig. 5-166. Fillister head screws

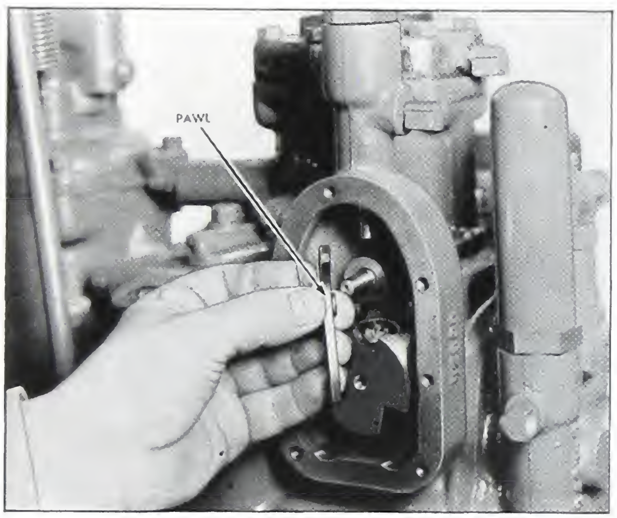


Fig. 5-167. Installing pawl

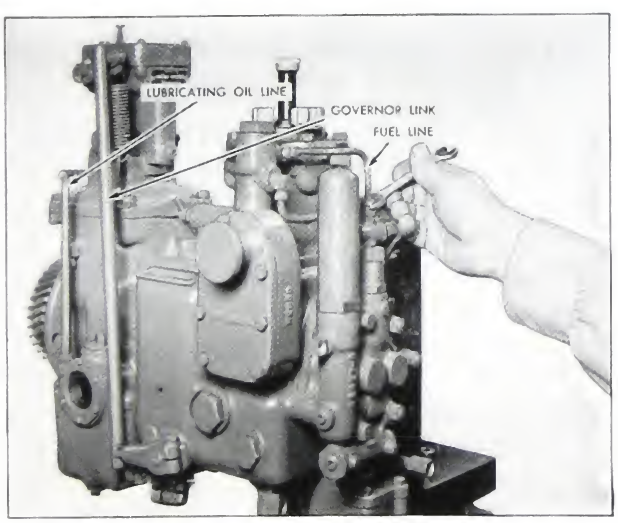


Fig. 5-168. Fuel connections

4. Before installing the pawl, make sure the end of the pawl which holds the valve in running position is not worn or rounded. Should this condition exist, faulty action would result.

5. Assemble the pawl and spring over the pin. See that the pawl fits under the valve stem in proper position. Shift the pin in the housing, if necessary, to align properly. Fig. 5-167.

6. Assemble the cover with a gasket to the housing and secure with capscrews and lockwashers.

7. Set the reset knob in running position.

FUEL AND LUBRICATING OIL TUBING AND LINKAGE—Hydraulic: 1. Assemble the lubricating oil supply and vent lines to the governor, governor drive housing and main housing. Fig. 5-168.

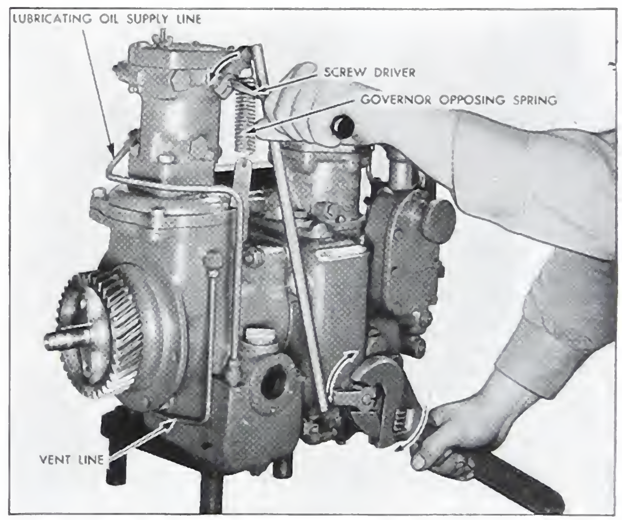


Fig. 5-169. Setting governor linkage

The lubricating oil supply line delivers lubricating oil from the governor sump to the gear pump in the base of the hydraulic governor. After this oil is used to activate the power piston of the hydraulic governor, it drains back to the sump through the drilled governor drive shaft. The vent tube provides ventilation from the engine crankcase to the governor drive housing.

2. Install the fuel lines to the gear pump assembly, overspeed stop, distributor, and priming pump connections.

3. Assemble the governor opposing spring to the upper governor lever and to the spring clip.

4. Loosen the clamp holding the upper governor lever to the governor terminal shaft. Push

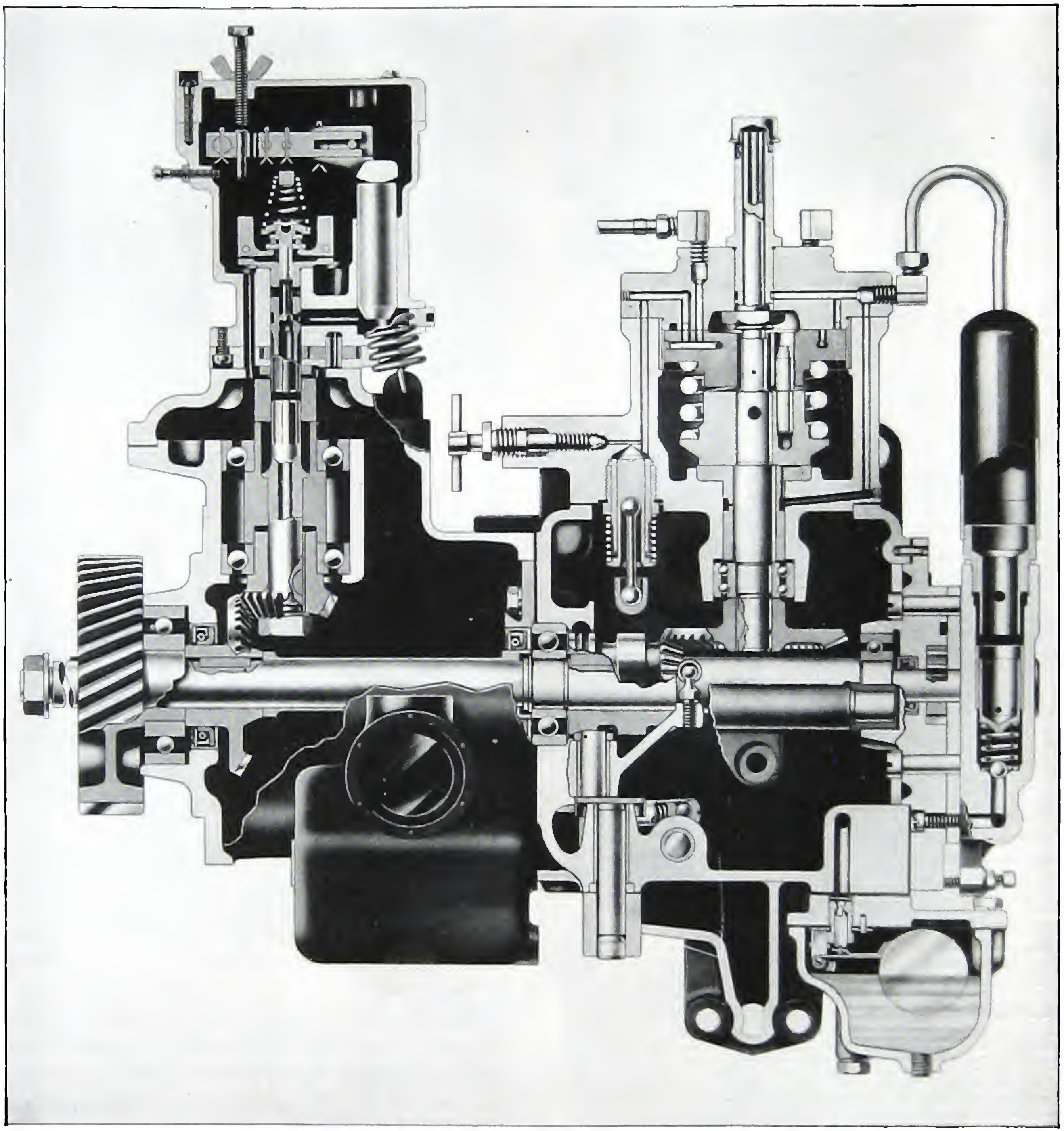


Fig. 5-170. Cross section, hydraulic type fuel pump

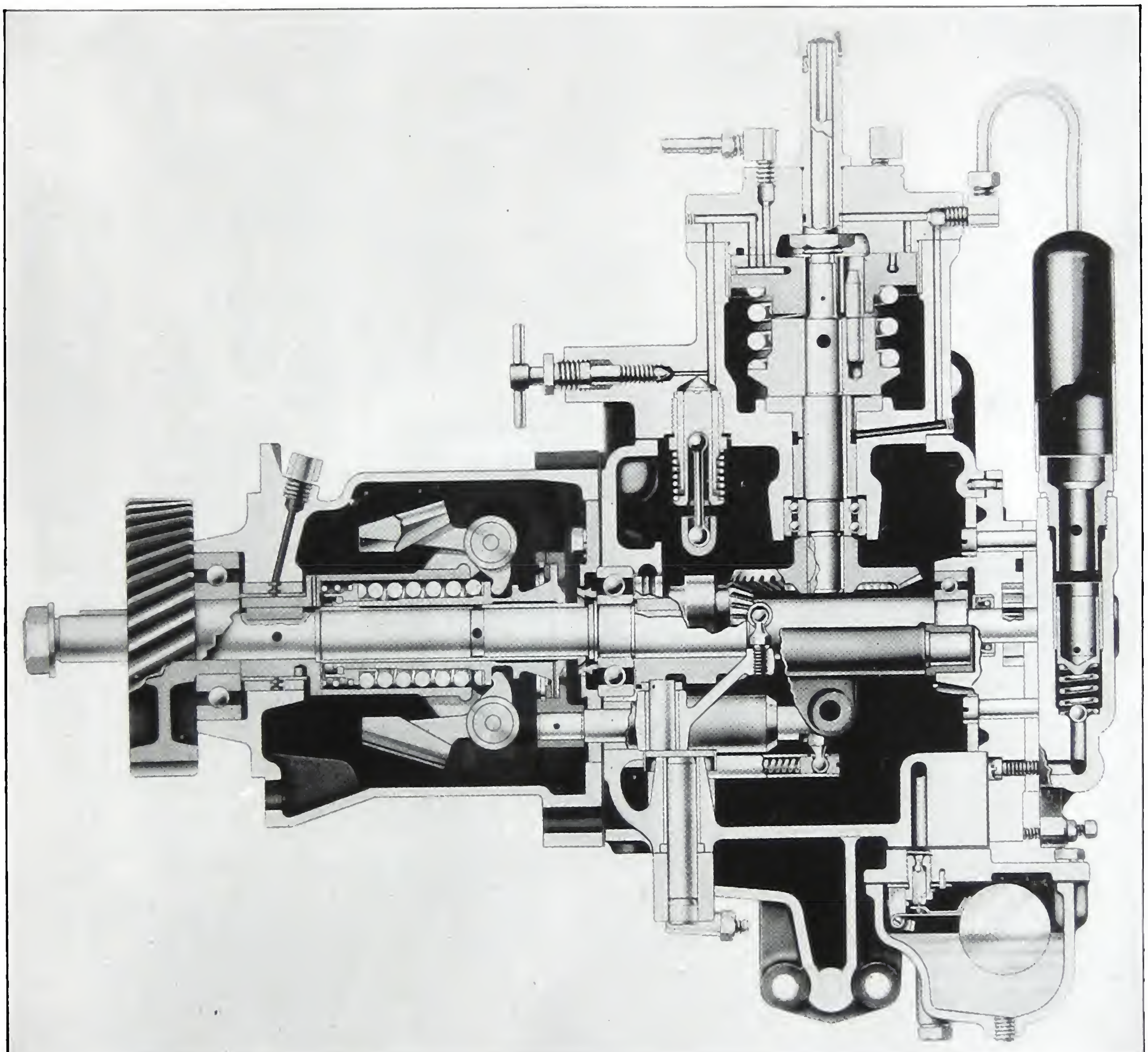


Fig. 5-171. Cross section, less compressor type fuel pump

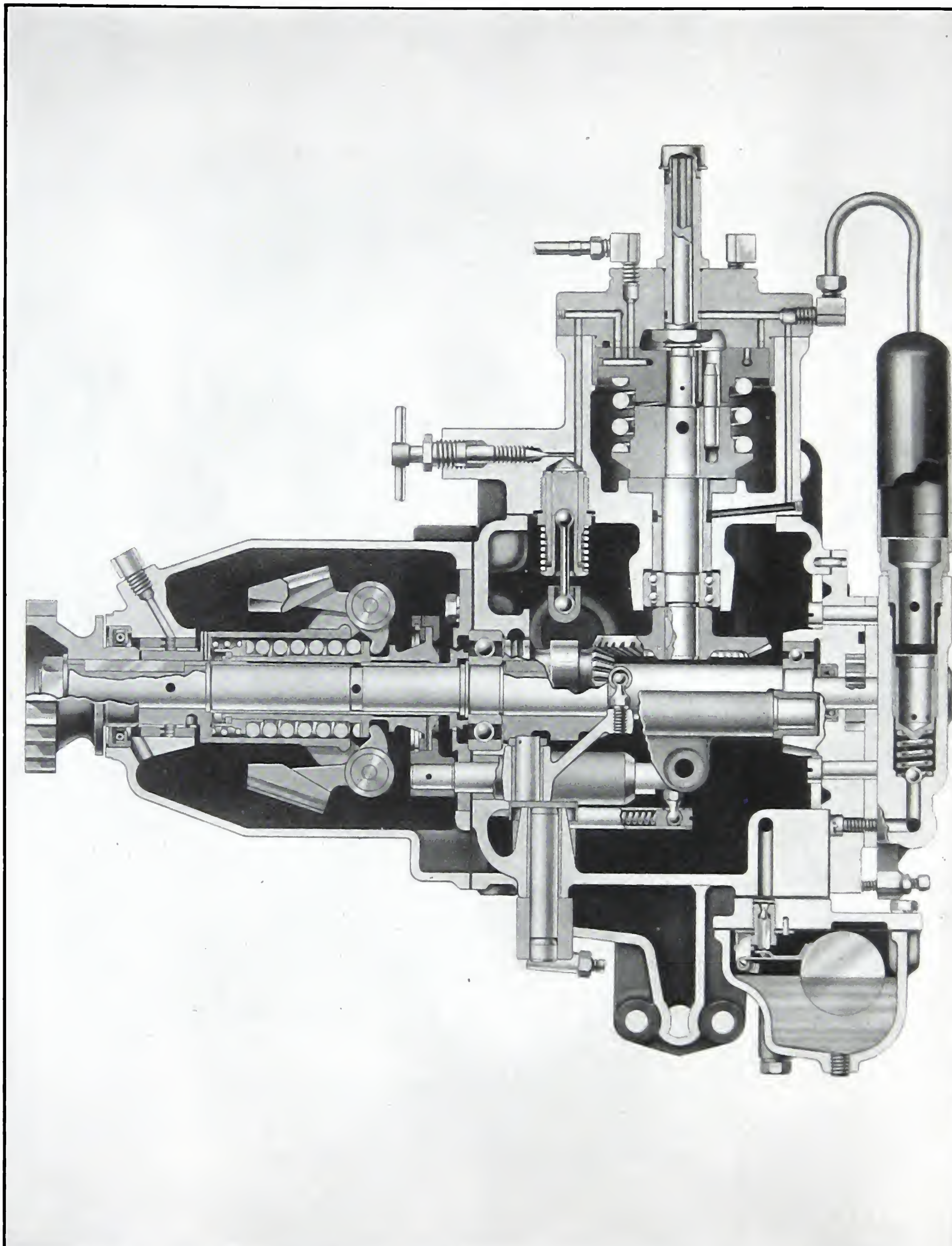


Fig. 5-172. Cross section, compressor type fuel pump

down on a wrench handle, as illustrated, to lift the governor control link until a stop is reached. This represents the limit of travel (in the full load direction) of the governor control shaft and linkage. While holding the linkage in this position, insert a screwdriver in the slotted end of the governor terminal shaft and turn counter-clockwise to the stop. Tighten the clamp. The governor to pump linkage is now set for proper engine operation. Fig. 5-169.

5. Fill the governor sump in the governor drive housing with clean lubricating oil, of the same grade as used in the engine, to the halfway mark on the glass inspection plate.

6. Check to be sure that:

a. The emergency control valve is OPEN.

b. The priming valve is CLOSED.

c. The overspeed stop is in RUNNING POSITION.

DOUBLE DISC (DD) FUEL PUMP

The DD Fuel Pump is available with either a mechanical or hydraulic governor. The hydraulic governor mounts on an independent drive unit with a self-contained oil sump. See Fig. 5-173, Fig. 5-174 and Fig. 5-175. Instructions are included for both types of fuel pumps and the governor drive unit. Governor repair is described on Pages 5-19 and 5-43.

The DD fuel pump is particularly adaptable to sub-assembly replacements. Camshaft assemblies, gear pump assemblies, governor assemblies, etc., can be removed and replaced easily with new or rebuilt units.

Nearly all capscrews used in the pump are socket head, and most of them have a 3/16" socket for one size wrench.

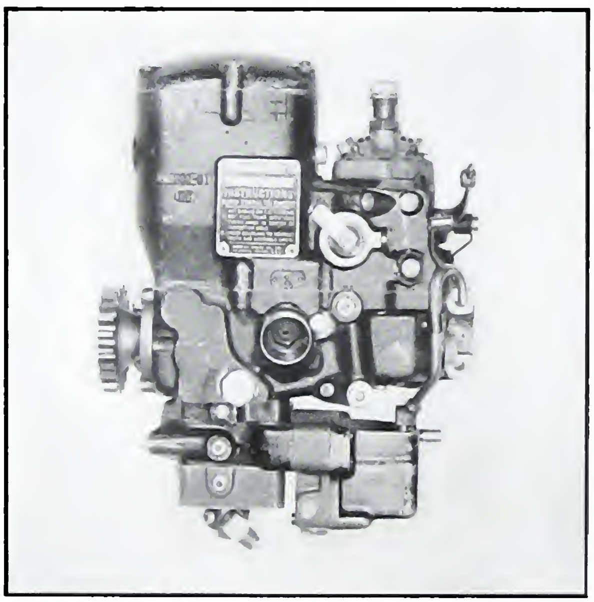


Fig. 5-173. DD fuel pump with maximum-speed mechanical governor

Assembly of the pump to the engine is covered in a later section of this manual.

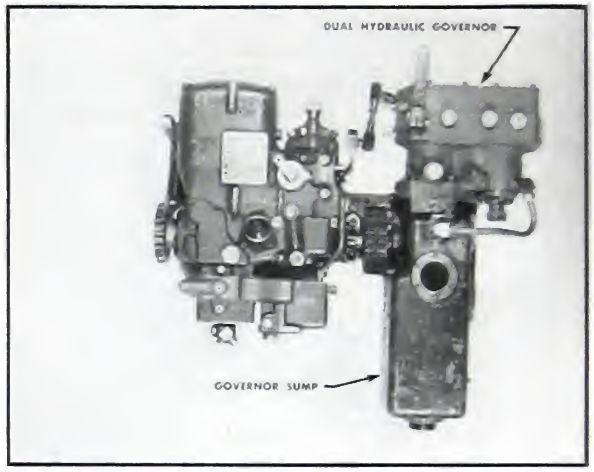


Fig. 5-174. DD fuel pump with hydraulic governor

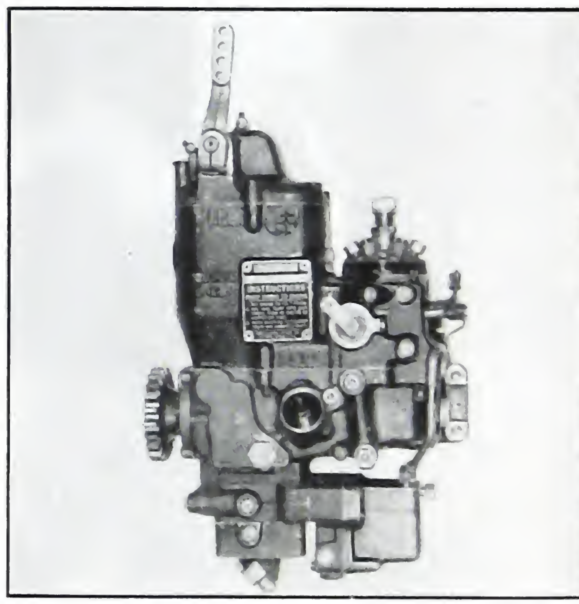


Fig. 5-175. DD fuel pump with variable speed mechanical governor

REMOVAL OF UNITS AND CLEANING

Clean The Pump

The fuel pump must be thoroughly cleaned on the outside before disassembly. This is especially important when a pump requires a unit exchange. When a new unit is put on a dirty pump, some dirt is likely to get into the new unit and it would soon fail.

1. Cover all inlets and outlets to the fuel pump.

2. Use mineral spirits or other solvent, *not harmful to aluminum*, and clean the exterior of

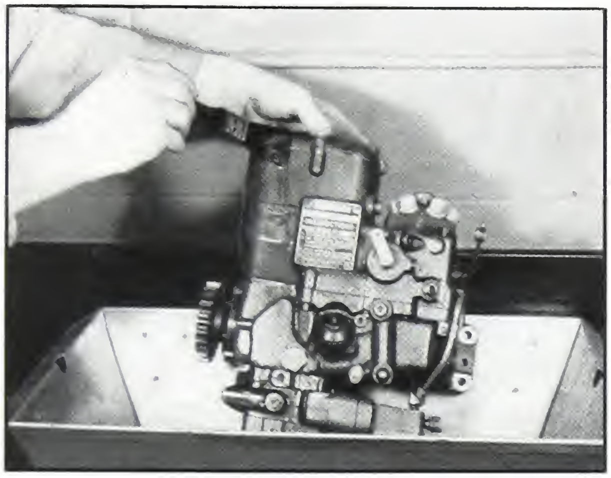


Fig. 5-176. Cleaning the fuel pump

the pump. Fig. 5-176.

3. Dry the fuel pump with compressed air.

Vise And Holding Fixture

Mount the pump on a good holding fixture. ST-302 Vise has a ball clamp joint to permit holding the pump in almost any position for easy assembly and disassembly. ST-303 Holding Fixture adapts the vise to the DD pump. The pump is held to the fixture by two dowels and two extended head capscrews. Fig. 5-177.

Discharge Cover And Disc

1. Remove the tachometer adaptor from the discharge cover.

2. The discharge cover is held to the distributor housing by six capscrews. To remove: Take out alternate capscrews and then back out the last three capscrews alternately to relieve

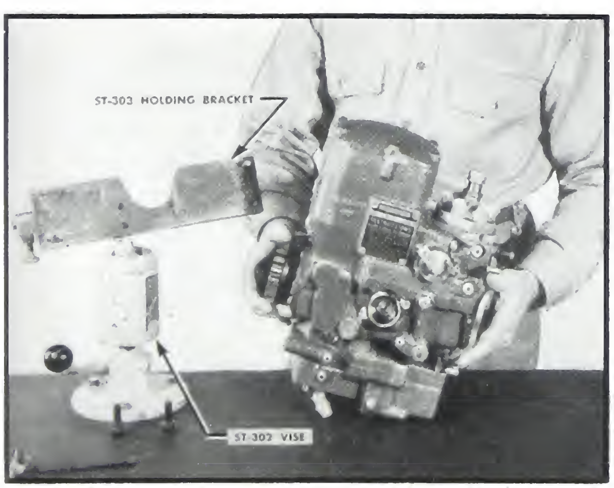


Fig. 5-177. Vise and holding fixture

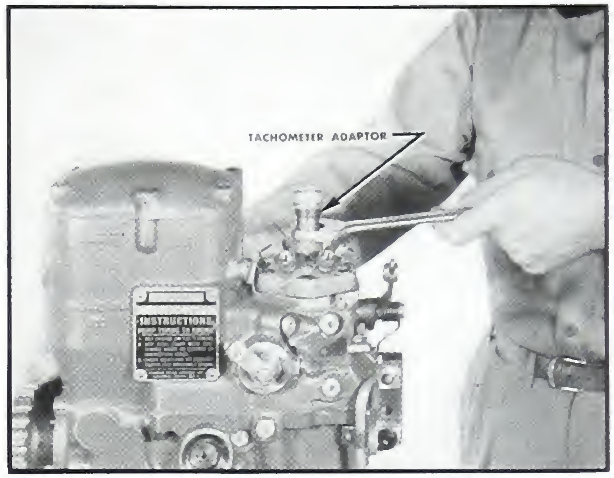


Fig. 5-178. Removing tachometer adaptor

the spring loading.

3. Remove cover and disc. Take care to prevent dropping the disc. Fig. 5-179.

4. Lift out the distributor spring. Fig. 5-332.

Inspection Of Suction Disc And Plate

1. The suction disc and plate can be inspected without removing the upper housing. Fig. 5-181. A two-pronged wire hook like that shown in Fig. 5-180 is handy to lift the suction disc out of the distributor housing.

2. If the disc is hard to lift out, remove the pipe plug and pry the disc up with a small screw driver. Fig. 5-180.

CAUTION: PRY ON THE DISC COLLAR, BEING CAREFUL NOT TO SLIP BETWEEN THE DISC AND PLATE MATING SURFACES.

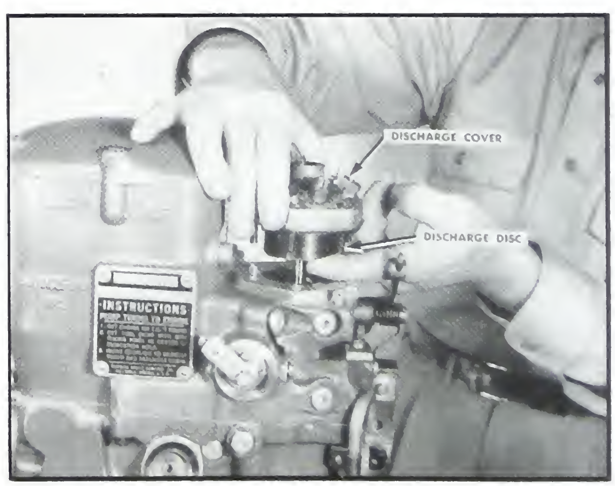


Fig. 5-179. Removing discharge disc and cover

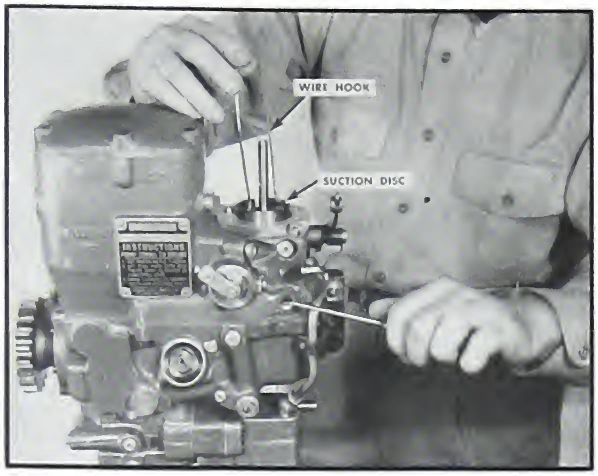


Fig. 5-180. Removing suction disc

Mechanical Governor

The instructions contained under "Mechanical Governor" heading pertain to mechanical governed fuel pumps only.

GOVERNOR HOUSING COVER: The governor housing contains either the maximum-speed or variable-speed mechanical governor and control units. To gain access to the governor unit: Remove the six ¼" screws and lift off the governor housing cover. Fig. 5-181.

GOVERNOR CONTROL UNITS: 1. Unscrew the four screws, and lift off the governor top support. Fig. 5-182.

2. Lift the governor springs off the governor shaft.

3. Loosen the ¼" socket head clamping screw on the governor lever and the two socket head

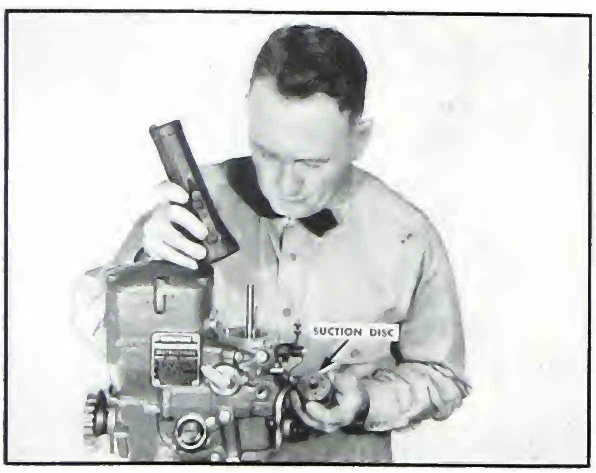


Fig. 5-181. Inspection of disc and plate

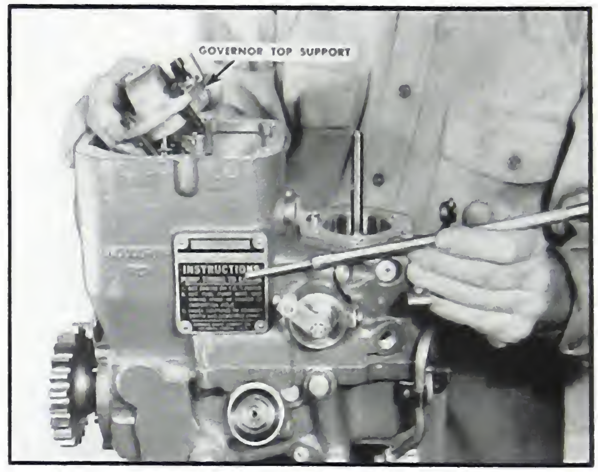


Fig. 5-182. Remove governor top support

screws in the governor yoke. Fig. 5-183.

4. Lift out the governor sleeve, thrust bearing and sleeve guide.

5. Take out the ⅜" pipe plug from distributor end of governor housing. Fig. 5-184. Drive the governor control shaft and front plug from the housing.

GOVERNOR DRIVE SHAFT, SUPPORT AND WEIGHT CARRIER: To remove the governor support and weight carrier assembly, loosen the two ¼" capscrews from the governor support and lift out the support and weight carrier assembly. Fig. 5-210.

Hydraulic Governor

1. Remove the upper housing cover.
2. Loosen the ¼" socket head clamping screw on the governor lever.

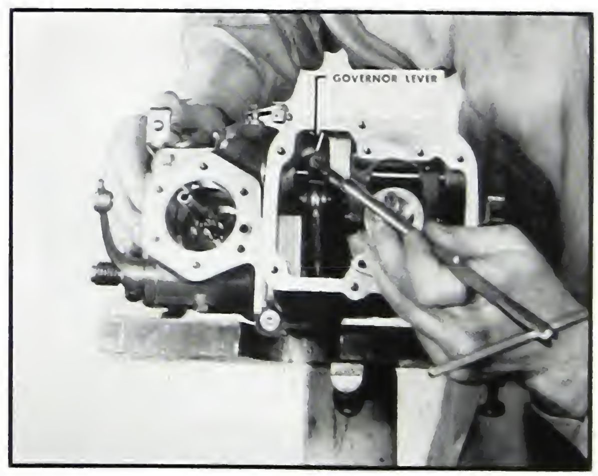


Fig. 5-183. Loosen governor lever

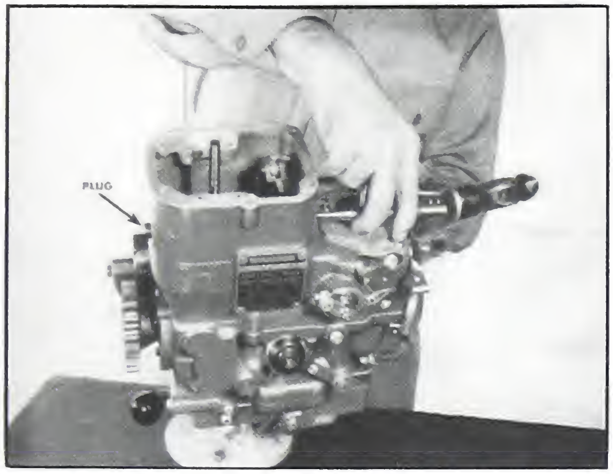


Fig. 5-184. Removing governor control shaft

3. Take out the pipe plug at the distributor end of the housing and drive out the governor control shaft. Fig. 5-184.

Float Chamber And Pump Assembly

The float chamber mounts to the side of the gear pump assembly which, in turn, is mounted on the bottom of the fuel pump main housing.

1. Remove the vent tube clamp mounting screws. Fig. 5-185.
2. Unscrew the four capscrews from the base of the gear pumps and lift the gear pumps and float chamber from the fuel plug. Fig. 5-186.

Fuel Pump Screen

The fuel pump screen on pumps with manual overspeed stop is attached to the large nut located immediately above the gear pump. Fig. 5-187. Remove the screen and clean thoroughly in mineral spirits.

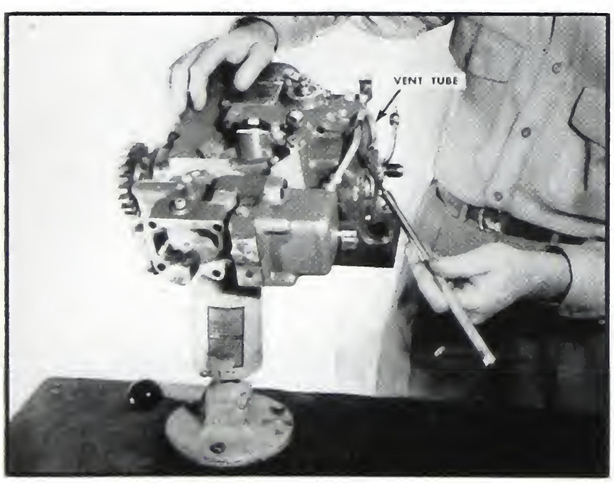


Fig. 5-185. Remove vent tube clamp

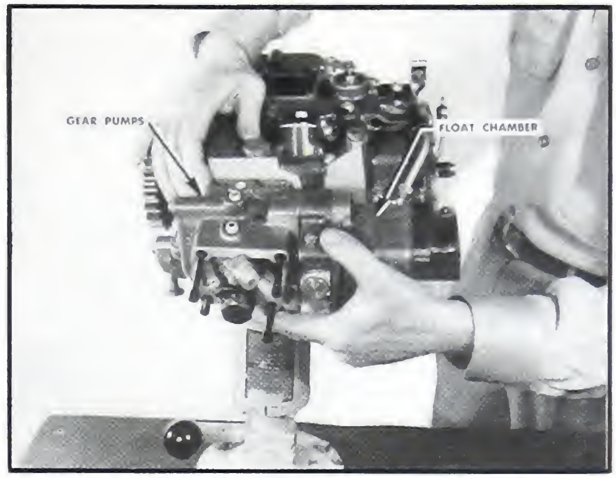


Fig. 5-186. Removing gear pump assembly

Automatic Overspeed Stop

The automatic overspeed stop assembly is held to the fuel pump main housing by three socket head capscrews. On this model pump, the fuel pump screen is in the stop assembly. Fig. 5-188.

Throttle Return Spring

A spring to return the throttle lever to idle position is located over the end of the throttle control shaft. Remove the spring from the post in the housing and slip the spring and sleeve from the eccentric shaft. Fig. 5-189.

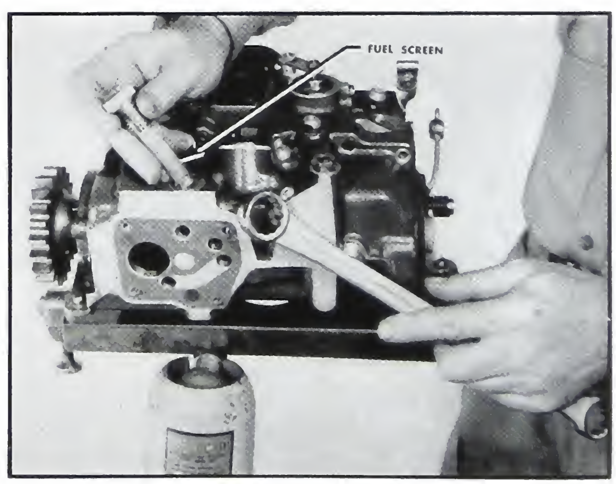


Fig. 5-187. Remove fuel pump screen

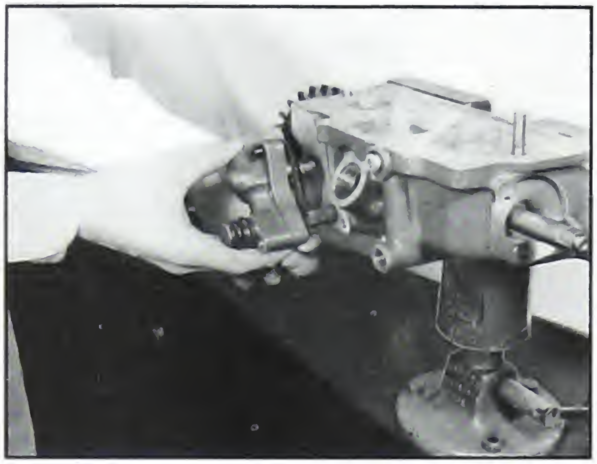


Fig. 5-188. Automatic emergency stop

Cam Rocker Spring

Unscrew the cam rocker spring retainer cap and remove cap, spring and gasket. Fig. 5-190.

Upper Housing

To gain access to the linkage, vertical lever, metering plunger, cam rocker lever and suction plate, the upper housing must be removed.

The upper housing is held to the main housing by nine capscrews. Remove as follows:

1. Remove the idle-fuel adjusting-screw pipe plug. Fig. 5-191. This must be removed to gain access to the upper housing hold-down screw.

2. Remove the nine socket head screws. Six screws are located around the outside of the fuel pump, and three must be removed from inside the governor housing. Fig. 5-192 and 5-193. Use

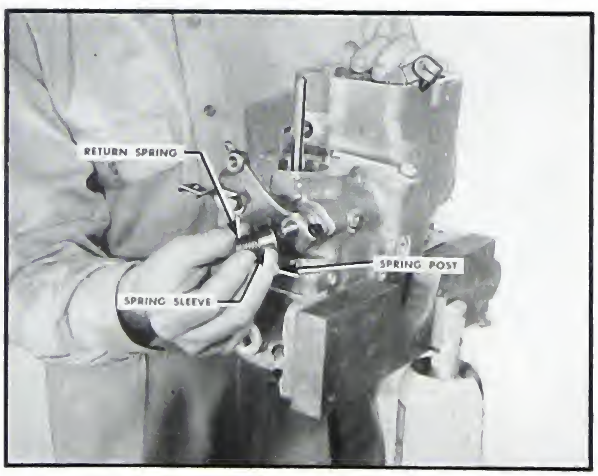


Fig. 5-189. Remove return spring and sleeve

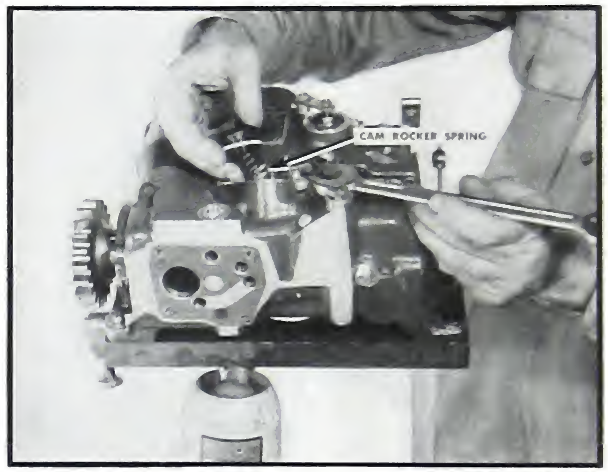


Fig. 5-190. Remove cam rocker spring

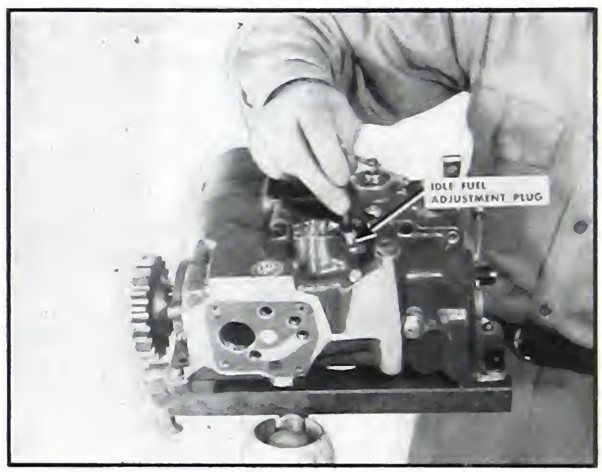


Fig. 5-191. Remove pipe plug

Fig. 5-192. Remove interior housing screws

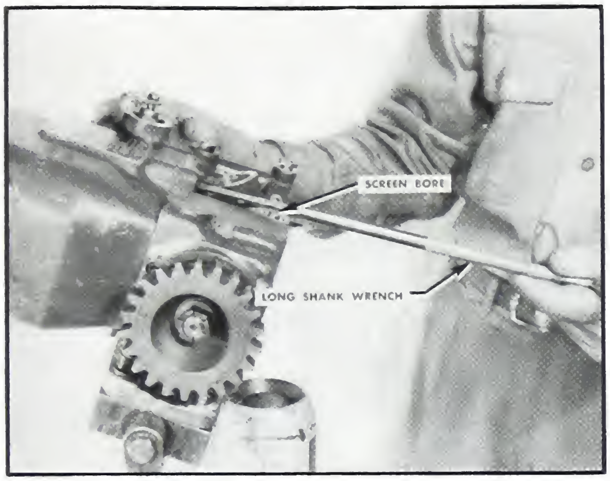


Fig. 5-193. Remove housing screws—exterior

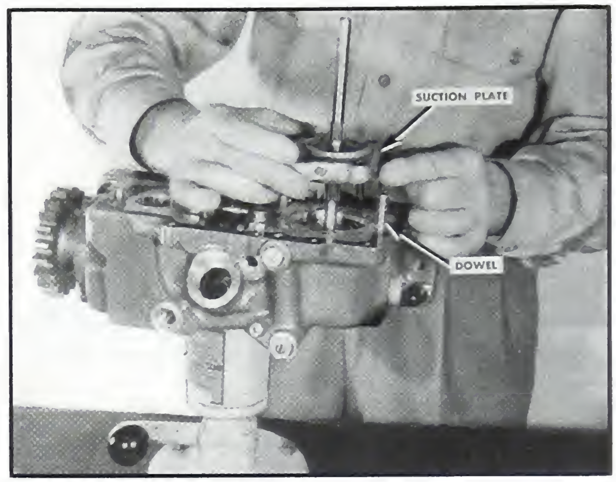


Fig. 5-195. Loosening suction plate

a long shank wrench to prevent damage to the face of the screen bore.

3. Using one hand inside the governor housing to hold up the vertical lever, lift off the upper housing. Fig. 5-194.

Suction Disc And Plate

The suction disc plate can be taken out after the upper housing has been removed.

1. Lift off the suction disc if not previously removed. Fig. 5-181.

2. Remove six ¼″ capscrews from the suction plate. Pry up on the suction plate near the locating dowels. Fig. 5-195.

CAUTION: USE A RAG OR A BLOCK OF WOOD AS A CUSHION TO PREVENT DAMAGE TO THE LOWER HOUSING.

Cam Rocker Lever Assembly

The cam rocker lever spring and the manual shut-down spring must be removed before the cam rocker lever assembly can be removed from the main housing.

1. Unscrew the cam rocker lever spring retainer cap and remove cap, spring and washer. Fig. 5-190.

2. Unscrew the manual shut-down spring cap and remove gasket, spring and shut-down retainer. Fig. 5-194.

3. Before removing the cam rocker assembly or main shaft and after the rocker lever spring and cap are disassembled, screw ST-356 in the cap hole. Mount the indicator on ST-356 and check the cam lobe lift. There are three lobes and the lift should be .119/.124 inch. Variance

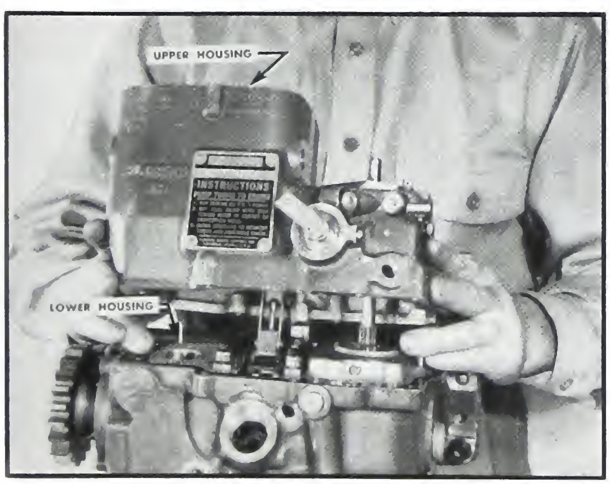


Fig. 5-194. Removing upper housing

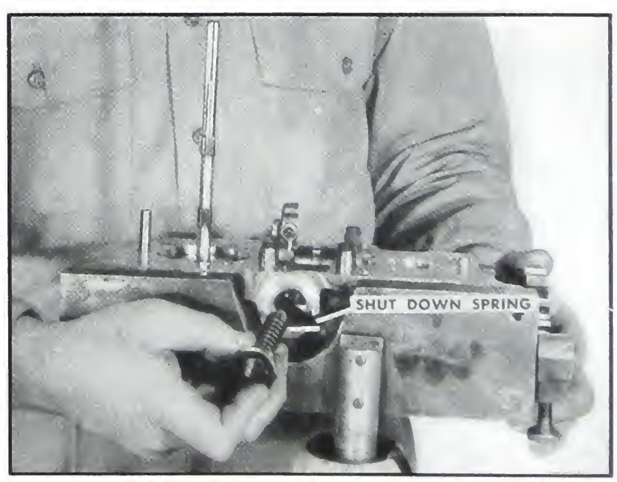


Fig. 5-196. Removing shut-down spring retainer

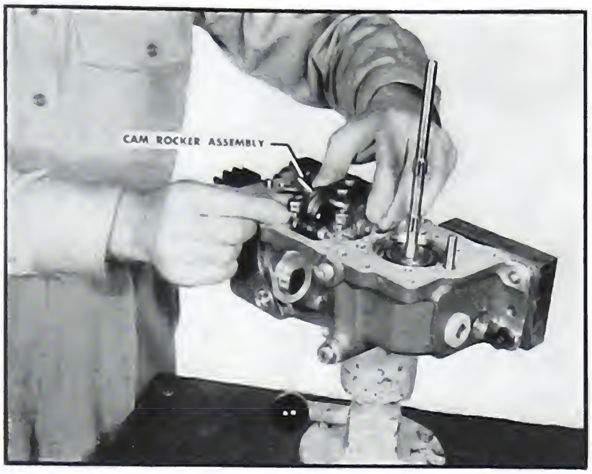


Fig. 5-197. Removing cam rocker lever brackets

between lobes on the same shaft should not exceed .002. Fig. 5-198.

4. Remove the four ¼" socket head holding screws from the cam rocker lever brackets. Use a screw driver to pry up on the cam rocker spring retainer arm while lifting up on the cam rocker assembly. Fig. 5-197.

CAUTION: USE CARE TO AVOID DAMAGING THE THREADS.

5. Remove the brackets.

Disc Drive Shaft Assembly

Mark mating teeth of disc drive shaft and main shaft gears to eliminate lengthy timing procedure during assembly; then drive out the disc drive shaft assembly after removing the pipe plug at the bottom of the main housing. On hydraulic governed pumps with a rear spider gear to drive the governor, it will be necessary

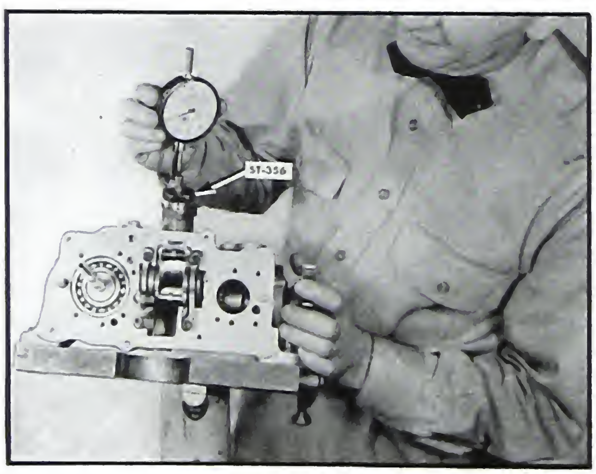


Fig. 5-198. Checking cam lobe lift

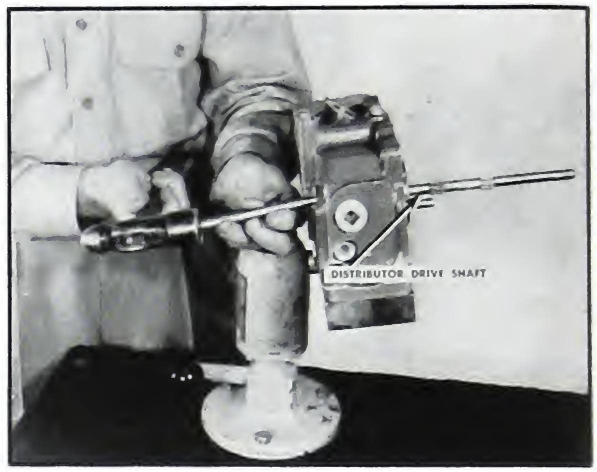


Fig. 5-199. Driving out disc drive shaft

to remove the main shaft before the drive shaft assembly. Fig. 5-199.

Main Or Camshaft Assembly

The camshaft assembly is held to the fuel pump main housing by the front bearing support.

MECHANICAL GOVERNED PUMP: 1. Remove the three capscrews from the front support.

2. The lower housing should be heated to 190° F, before pressing out the main or camshaft. This will also prevent damage to bearings.

3. Remove the ¾" pipe plug from the main housing and assemble the ST-391 driving plug to the main shaft.

4. Assemble the main shaft pressing tool, ST-391, to the housing and press and main shaft the housing. Fig. 5-200.

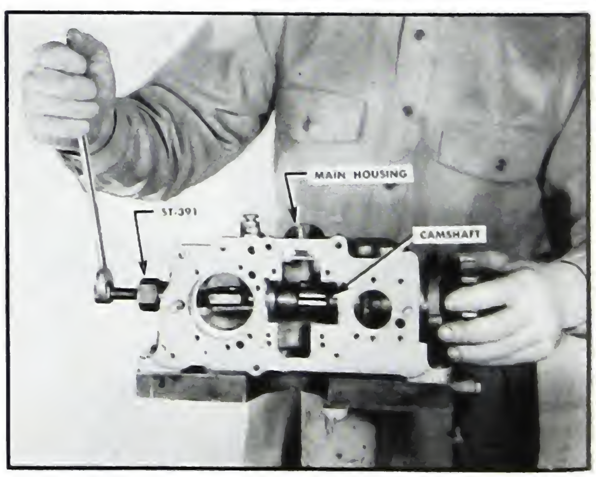


Fig. 5-200. Remove main shaft

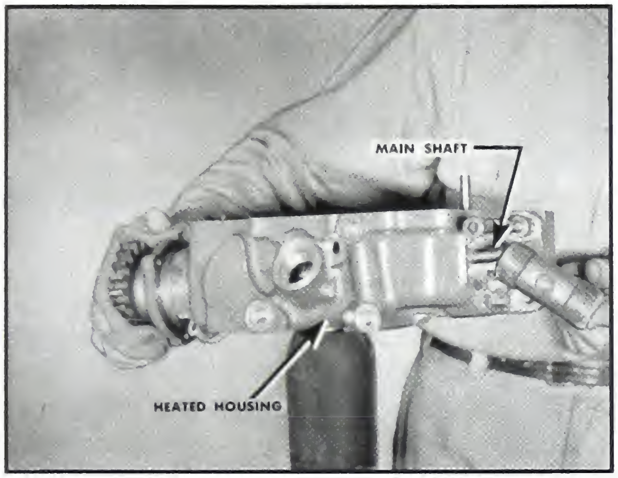


Fig. 5-201. Driving out main shaft—hydraulic-governed pump

HYDRAULIC GOVERNED PUMP: 1. Remove the rear half-coupling retainer nut and washer.

2. Use a gear puller and pull the rear half-coupling.

3. Remove the coupling oil seal and needle bearing retainer.

4. Slip the shaft spacers from the shaft.

5. Remove the three capscrews from the front bearing support bracket.

6. Press or drive out the main shaft assembly. Fig. 5-201.

NOTE: Heat the housing to 190° F. to ease main shaft removal.

UNIT REBUILDING

The following information has been set aside from unit repair instructions because it is applicable to more than one unit or sub-assembly. In this section, we are concerned only with fuel pump sub-assembly repair and rebuilding.

Parts must not be discarded until they are worn beyond reasonable replacement limits:

All fuel pump parts will continue to function long after they show some wear. The mechanic who automatically replaces all wearing parts soon throws away good parts that are worth more than the wages of a good mechanic.

Parts that are worn beyond reasonable replacement limits must not be re-used:

The good mechanic quickly learns the "reasonable replacement limits", and then he uses all parts that will give another complete period of service without danger of failure. By a "period of service", we mean the same service period between overhauls as set up for other engine unit replacements.

General Instructions

CLEANING: A clean shop, clean tools and good cleaning practices are essential to good quality fuel pump repair. Special care must be taken when cleaning aluminum alloy parts. Some cleaning solvents will attack and corrode aluminum.

Remember that time is seldom as important as a good job, and that cleaning time is always well spent. Most fuel pump failures occur because of dirt. Saving time by allowing dirt to cause another failure is always a waste of time.

INSPECTION: There are very few jobs in the shop that offer as many opportunities for saving parts and time as inspection. As little as five minutes spent on inspection may save several dollars worth of parts or prevent failure of the rebuilt pump.

Too often, inspection is regarded lightly and performed in a haphazard manner or not performed at all. Proper tools are essential to a satisfactory job of inspection.

TOOLS: Using proper tools has many advantages. From a safety standpoint, the proper tool will prevent damage to machined surfaces. Everyone appreciates the light weight of the DD pump. The light weight is made possible by the use of aluminum alloy parts, but aluminum is softer and more easily damaged than cast iron. Aluminum parts must be handled carefully.

All service tools are available from your Cummins Dealer.

An arbor press should be used for all pressing operations. Pressing is much better than driving for controlled pressure and alignment. Always make sure that the part is properly supported when pressing another part into it.

PRESSING LUBRICANT: A good extreme pressure lubricant should be used on mating surfaces in all pressing or driving operations. The lubricant prevents galling or scoring during assembly and disassembly. Be sure to remove all burrs from mating parts before pressing them together.

NEEDLE BEARINGS: The thin surface-hardened outer-shell of the needle bearing acts as the hardened outer race surface as well as a retainer for the rollers. After heat treatment, this shell may be out-of-round. It then becomes necessary to press the needle bearing assembly into a true round housing, and it must have an interference fit to restore the true round dimension necessary for efficient operation of needle bearings. Use a piloted mandrel and always press against the stamped end of the needle bearing.

Do not replace needle bearings unless inspection shows that it is necessary. Needle bearings will last much longer than bushings and replacement should be a relatively rare occurrence. As needle bearings are pressed in and out of bores, the bores enlarge and eventually it will be necessary to replace the housing. On the other hand, needle bearings are easy to replace and require no machining operations. If you use proper care and an extreme pressure lubricant, you should not experience any difficulty from replacing needle bearings in the few cases where it will be necessary.

Water or acid in the fuel will ruin needle bearings as well as other fuel pump parts.

CAPSCREWS AND WASHERS: Normally, in this pump as in all assembled units, capscrews have an engaging thread length about one and one-half to two times the diameter. Observance of this rule will prevent stripping threads with a screw that is too short or breaking a part from using a capscrew that is too long.

Lockwashers must *never* be used next to aluminum. *Always* use a flat steel washer between the lockwasher and the aluminum housing.

PARTS REPLACEMENTS: Always determine the need, *if possible,* before disassembling the unit and then replace only the parts which need replacement.

Instructions for complete disassembly and parts replacements are given in this section not because you will need to perform all operations on all pumps, or on any one pump, but only to supply you with instructions as you need them.

Distributor Discs And Covers

The discs and covers used in the DD Pump must be ground and lapped to such close tolerances as to exclude field repair. However, scored and worn discs can be sent back to the factory and reground as many as three or four times so long as the grinding does not exceed the .040" to .050" thickness of the hardened mating surfaces. A cracked disc can not be repaired. Fig. 5-202.

The distributor cover contains the top support needle bearings for the distributor shaft and an oil seal. If either of these is damaged it should be pressed out and replaced. Always protect the cover or disc mating surfaces from scratches, scores, etc.

1. Press in the needle bearing until it is flush with the bottom of the oil seal counterbore. Turn cover over and make sure the hole at the base of the needle bearing is not covered. Fig. 5-203.

2. Press the oil seal down to the bottom of its counterbore. The seal lip goes down. Fig. 5-204.

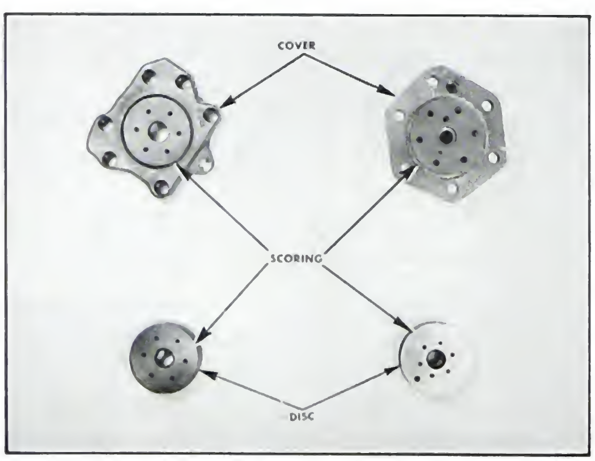


Fig. 5-202. Disc and cover

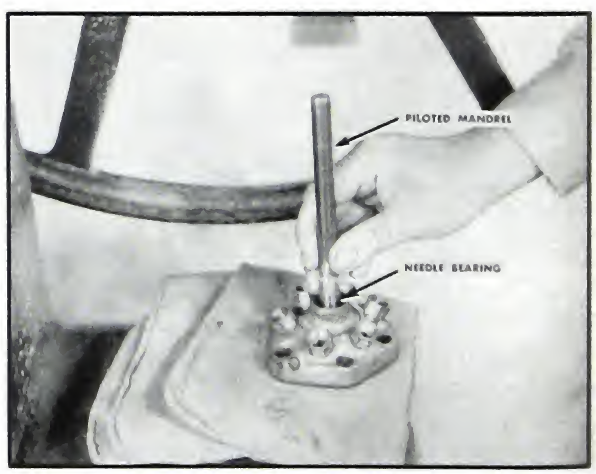


Fig. 5-203. Replacing needle bearing

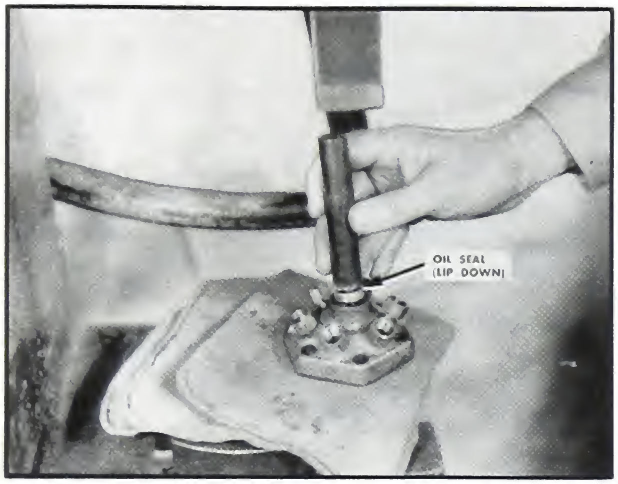


Fig. 5-204. Replacing oil seal

DISTRIBUTOR DISC SPRING: Fig. 5-337. Free length—2.137 inch, load @ 1 13/32 inch—300 lbs. to 320 lbs.

Distributor Shaft And Ball Bearing

If either the gear or ball bearing needs replacing, it should be replaced as an assembly. This assembly is a tight press fit and the ball bearing can not be removed without damage to the bearing races.

Governor Control Units

IDLING SPRING: The idling spring should be checked on a standard spring tester according to the following dimensions: Refer Fig. 5-205.

Load @ .571 inch = 36.3 to 40.1 lbs.
Load @ .727 inch = 14.3 to 15.1 lbs.

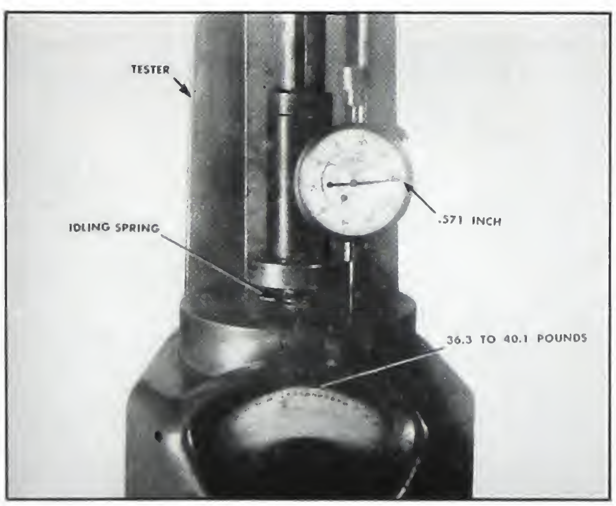


Fig. 5-205. Checking spring tension

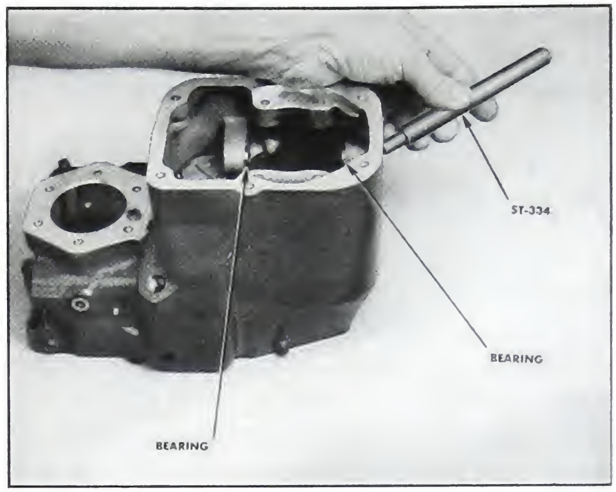


Fig. 5-206. Installing new governor control shaft bearing

CONTROL SHAFT AND BEARINGS: The governor control shaft will not need replacing unless it shows evidence of brinelling. Brinnelling can be detected by rotating the shaft under direct light rays. Alternate bright spots are brinelled valleys caused from wear and impact loads. In most cases replacing of a brinelled shaft requires replacement of the needle bearings. Needle bearings should be checked with a new shaft for freeness, sticking and diametral clearance. Diametral clearance between the shaft and needle rollers should be between .0005 and .0029 inches. To replace:

1. Drive out both inner and outer bearings with ST-334. See Fig. 5-206. The governor-shaft oil seals can be driven out with the needle bearing tool.

2. Coat with extreme pressure lubricant and,

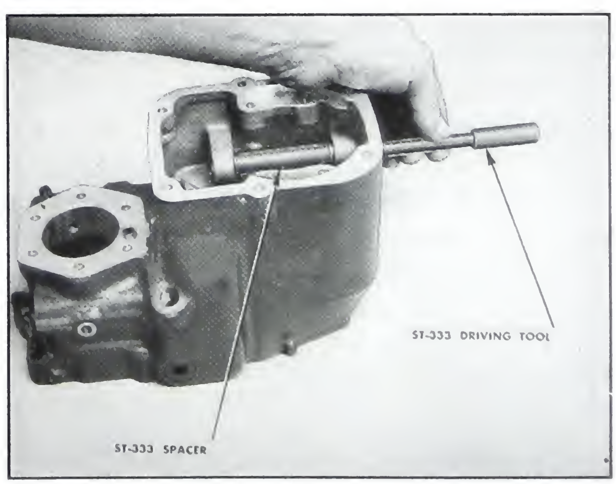


Fig. 5-207. Spacing control shaft bearings

using ST-334 tool, drive the inner bearing to its approximate position. Always drive against the stamped end of a bearing. See "General Instructions for Needle Bearings," Page 5-67.

3. Drive outer bearing to its approximate position with ST-333 driver and spacer. Refer to Fig. 5-207.

4. Remove spacer; insert yoke on ST-333 driving tool in place of spacer, and check the mechanical governor yoke's center position with relation to the governor drive shaft.

5. Remove yoke; insert ST-333 spacer, and drive bearings to proper center position. Recheck yoke center position.

6. Replace governor shaft oil seals.

THRUST BEARING: Check the thrust bearing for wear, flat spots and free movement. See Fig. 5-210.

SLEEVE GUIDE: The sleeve guide is provided with a stellite insert to bear against the high-speed weight pawl and it should not show any appreciable wear. Refer to Fig. 5-210.

SLEEVE: Inspect the sleeve yoke roller for flat spots and wear. Replace if worn smaller than .370″ outside diameter. Refer to Fig. 5-210.

To replace the roller: Remove the pin clamp from the sleeve pin. Check the sleeve pin. Replace new if worn beyond .246″ outside diameter. The sleeve pin is easily pressed out with an arbor press.

YOKE: The governor yoke has hardened wearing surfaces where it bears on the yoke rollers. Check for free action. A shiny spot only indicates the running position, and is not serious until the mark is deep enough to interfere with the free action of the yoke on the roller. See Fig. 5-210.

MAXIMUM SPEED SPRING: ST-311 fixture is handy to disassemble the maximum speed spring. Fig. 5-208. This spring assembly is used in maximum-speed mechanical governors only.

1. Compress the spring and remove spring retainer.

2. Assemble the maximum spring to the maximum-spring sleeve and guide with three spacers on one end and two on the other end of spring. Refer to Fig. 5-209. This is an approximate setting and should be checked further on the fuel pump test stand. Remove or add spacers as needed. One spacer changes the maximum speed approximately 6 or 7 rpm. See Fig. 5-209.

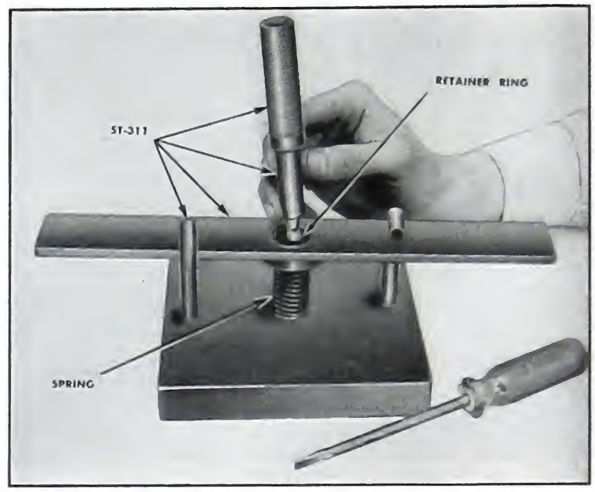


Fig. 5-208. Removing spring retainer

3. Following is a tabulated list of springs and weights:

Engine RPM	Use Spring	Idling Weight	Maximum Speed Weight
1200 rpm	68333	67993	68410
1400 rpm	69353	67993	67988
1550 rpm	69001	67993	67988
1650 rpm	68333	67993	67988
1800 rpm	68407	67993	67988
2100 rpm	68250	67993	67988

4. Use ST-311 fixture and compress the spring to insert the spring retainer. Fig. 5-208.

SPRING DATA:

Spring Part No.	Free Length	Load @ 1.786 in.	Load @ 2.00 in.
68333	2.391	64.1 lb. to 75.1 lb.	41.0 lb. to 49.0 lb.
68407	2.740	69.7 lb. to 77.1 lb.	54.2 lb. to 59.8 lb.
68250	2.980		72.0 lb. to 80.0 lb.
69001	2.650	57.8 lb. to 55.8 lb.	35.0 lb. to 43.0 lb.
69353	2.600	35.2 lb. to 46.2 lb.	26.0 lb. to 34.0 lb.

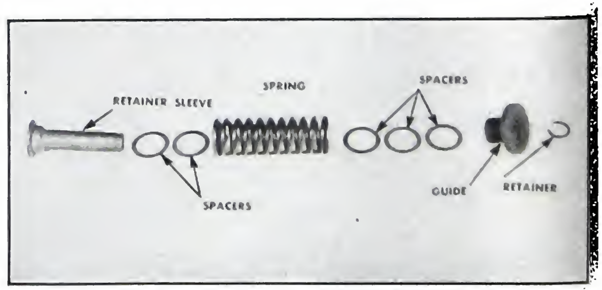


Fig. 5-209. Maximum speed spring assembly

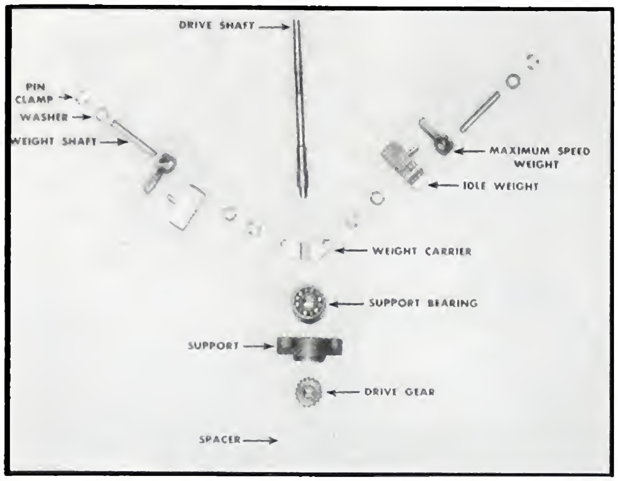


Fig. 5-210. Exploded view governor weight carrier support and drive shaft

Governor Weight-Carrier Support And Drive Shaft

GOVERNOR WEIGHT-CARRIER: The following instructions apply to both the standard and variable-speed mechanical governors.

1. Remove the retaining "E" rings from the ends of the governor weight shaft. Remove the shafts, weights and spacer washers. Fig. 5-211.

2. Inspect the shafts for wear and size. Do not use the shaft if it is worn beyond the limit of .3745. Check the shaft for brinelling by rotating the shaft under a light, and examine it for bright spots. Use the shaft to check the needle bearings in the high-speed weight. If the shaft binds or sticks in these bearings they should be replaced. A brinelled shaft usually requires replacement of the needle bearings.

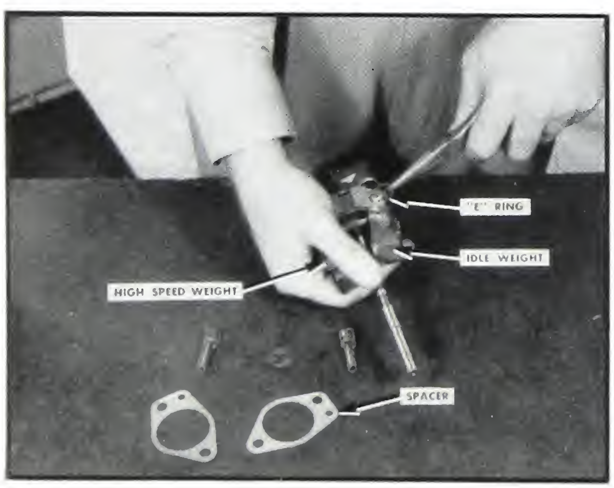


Fig. 5-211. Remove "E" rings

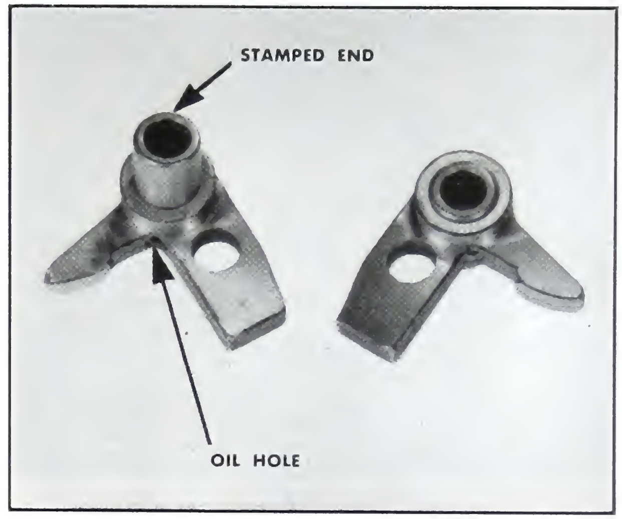


Fig. 5-212. Oil holes in maximum speed governor weight

3. To replace needle bearing, press out the old bearing and press in a new one with ST-337 mandrel until it protrudes an equal distance on each side of the weight. Be sure the oil hole in the bearing lines up with the oil hole in the high-speed weight. Fig. 5-212. Always use extreme pressure lubricant and press against the stamped end of the needle bearing.

4. The idling weight has no needle bearing but it can be checked in the same manner as the high-speed weight. Replace new if the shaft hole is larger than .3795 diameter, or if clearance between shaft and weight-shaft hole is more than .007″.

5. Assemble weights, weight shafts and washers to weight-carrier and secure with retaining rings. Assemble 1/32″ washer between each

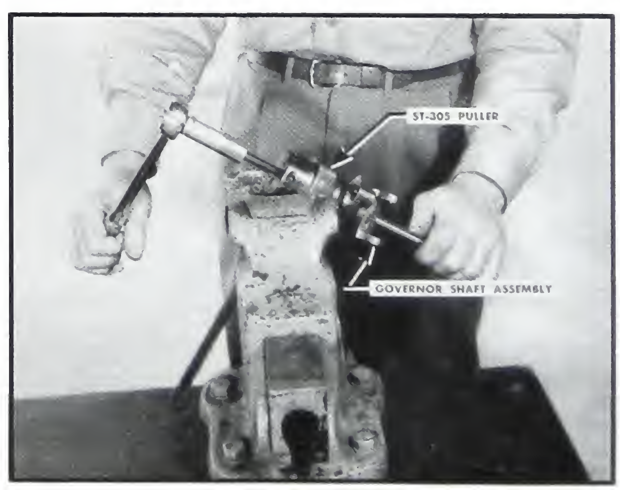


Fig. 5-213. Pull drive gear

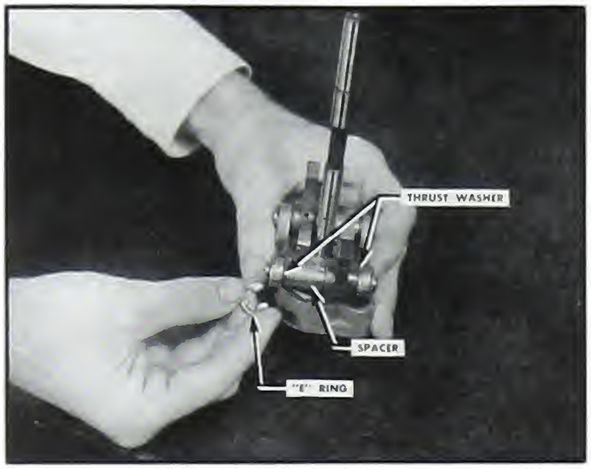


Fig. 5-214. Install variable-speed governor weights

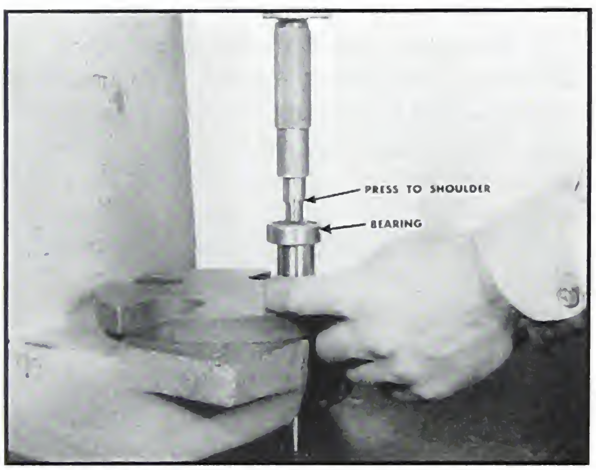


Fig. 5-215. Pressing on governor bearing

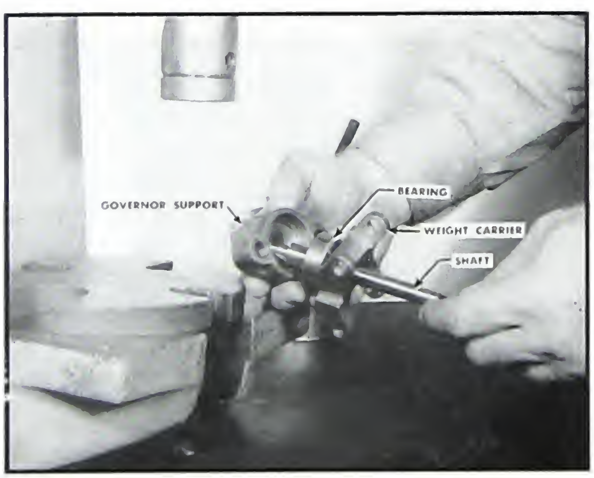


Fig. 5-216. Assembling weight carrier and shaft to support

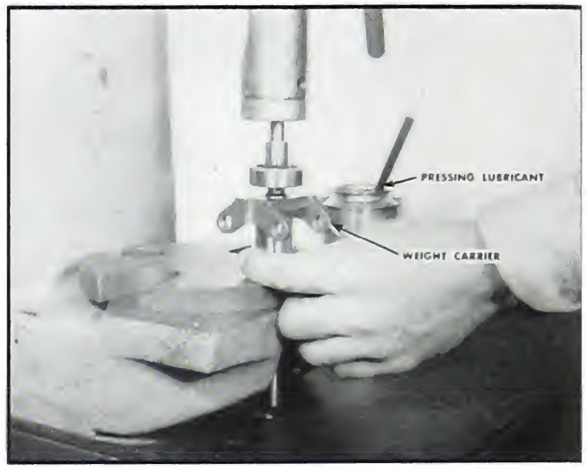


Fig. 5-217. Press on governor weight-carrier

weight and its corresponding weight carrier arm.

NOTE: The variable-speed governor has only one set of weights similar to the high-speed weights of the standard mechanical governor. Install a spacer on the leading side of this weight. The governor shown in Fig. 5-214 is for a right hand pump, reverse weight and spacer for left hand rotation fuel pumps. The weight-carriers too are slightly different and not interchangeable.

GOVERNOR SUPPORT AND DRIVE SHAFT: The governor drive gear, support bearing and weight-carrier are all assembled to the drive shaft with an interference fit. Check their condition before disassembly, and do not disassemble unless necessary.

1. Use ST-305 gear puller and pull the governor drive gear.
2. Press off the governor weight-carrier.

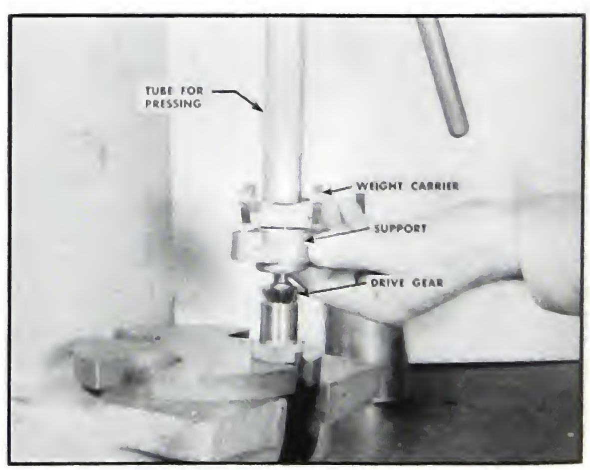


Fig. 5-218. Assembling driving gear

3. Press governor shaft out of the governor support bearing.

4. With extreme pressure lubricant on mating surfaces, press governor bearing in place. Fig. 5-215.

5. Slip the governor support over the governor bearing. This is a slip fit and pressing is not required. Fig. 5-216.

6. Press governor drive gear over the governor shaft. Fig. 5-218. To prevent damage to the governor shaft slide a piece of tubing over the shaft and press on it. A bent shaft will cause an early bearing failure.

Upper Housing

The linkage, metering pump and hand control eccentric described in succeeding paragraphs are located in the upper housing.

LINKAGE: 1. The vertical lever, fulcrum lever, overrun link and governor lever make up the linkage assembly. Fig. 5-226.

2. Remove the retaining ring from the eccentric shaft and lift out the linkage. Fig. 5-219.

3. Pull off retaining rings and disassemble linkage.

VERTICAL LEVER: 1. Inspect vertical lever roller for wear, scoring, sticking and roughness. Replace new if worn beyond .742 outside diameter.

2. When necessary, remove the vertical lever roller by pressing out the roller pin. If the roller pin is brinelled and must be replaced, the needle bearing must also be replaced. Fig. 5-220.

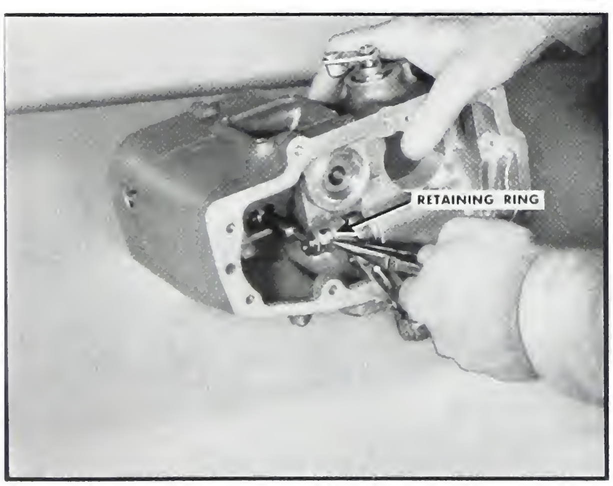


Fig. 5-219. Removing retaining ring from eccentric shaft

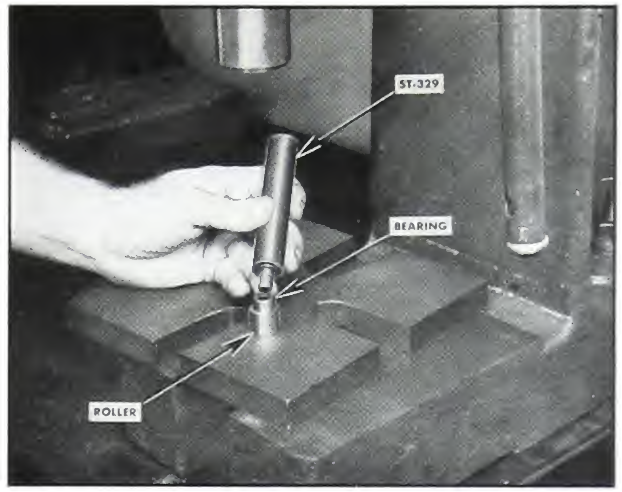


Fig. 5-220. Assembling bearing to roller

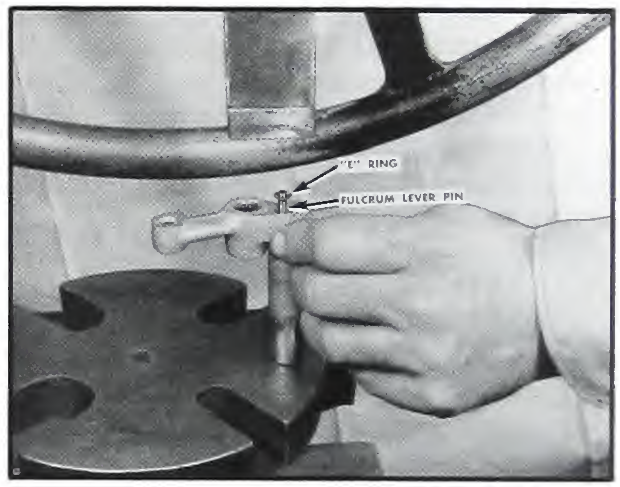


Fig. 5-221. Assembling fulcrum lever pin

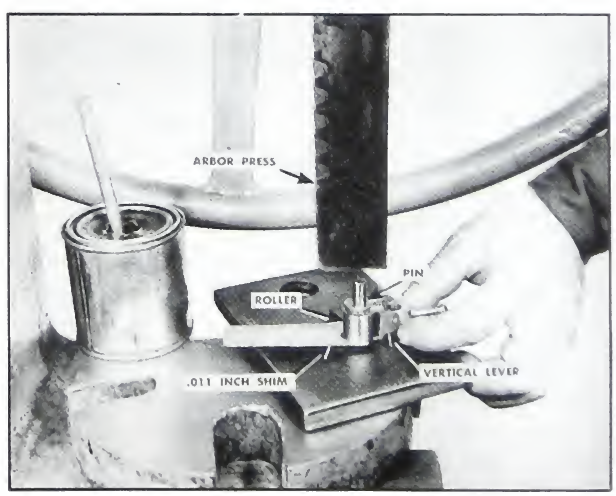


Fig. 5-222. Assembling roller to vertical lever

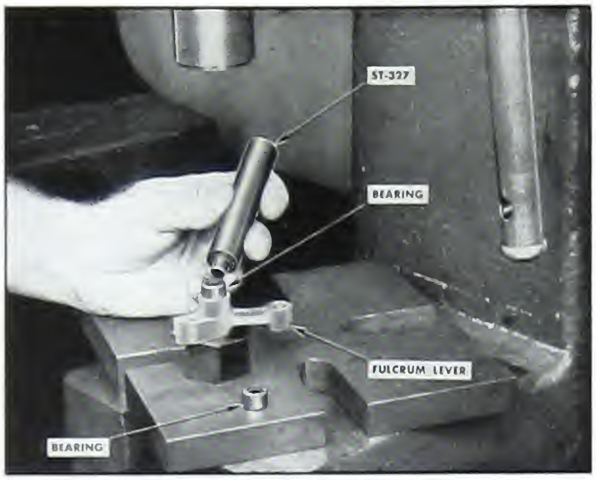


Fig. 5-223. Pressing in fulcrum lever needle bearings

3. The needle bearing is assembled to the roller with an interference fit, and it should be removed by pressing. Fig. 5-220.

4. To assemble, use ST-329 pressing mandrel. Fig. 5-220. See General Instructions.

5. Assemble roller to lever with vertical roller pin. Insert a .011 shim between roller and lever while pressing to maintain proper clearance and prevent distortion. Fig. 5-222. Check roller for free action.

6. Check link pin for wear and brinelling. Do not use old link pin if worn beyond .187 outside diameter. Check link pin needle bearing with a new link. When necessary, drive out and replace using ST-326 pressing mandrel. See "General Instructions" at beginning of this section.

FULCRUM LEVER: 1. The fulcrum lever is made of aluminum alloy and should be examined carefully before replacing needle bearings or fulcrum lever pin. Fig. 5-226 and 5-224.

2. If necessary, the two needle bearings at the fulcrum of the fulcrum lever can be pressed out and replaced. Use ST-327 to give proper spacing. See Fig. 5-224 and "General Instructions."

3. The fulcrum lever pin should not be replaced unless brinelled or worn beyond .187. When necessary, press out and replace; press new pin, with retaining ring in place, flush with lever surface. Fig. 5-221.

4. Check link bearing with a new link pin. When necessary, drive out and replace using ST-328 mandrel. Fig. 5-224.

5. Inspect link pin; replace if brinelled or worn beyond .187 outside diameter. A brinelled

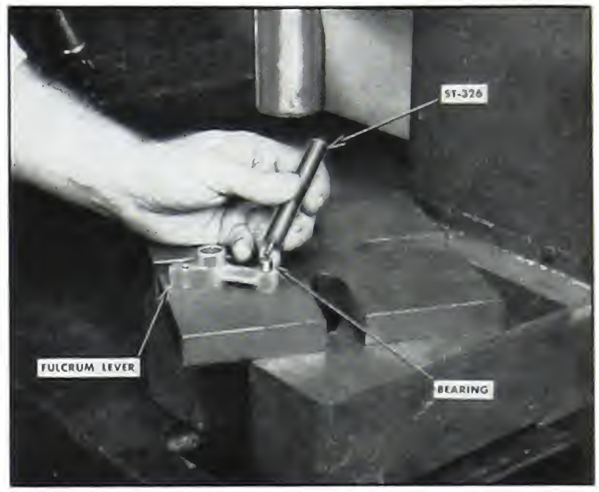


Fig. 5-224. Assembling link pin needle bearing to fulcrum lever

pin usually requires replacement of link bearing.

OVER-RUN LINK: 1. Use a new link pin to check link pin bearings for roughness, binding, etc. If necessary, drive out and replace new with ST-326.

2. Check for free action and spring tension. This is a close wound tension spring and can be checked by securing one end while hanging a 50 lb. weight on the outer. 50 lbs. should increase center-to-center length of over-run link 3/16 inch. Ends of spring should be flush with the ends of threaded portions of the link.

3. The spring has been screwed on to both the male and female sections of the link. To disassemble, screw off as shown in Fig. 5-225.

4. To reassemble, use an extreme pressure lubricant and screw spring on until flush with end of thread. See Fig. 5-225.

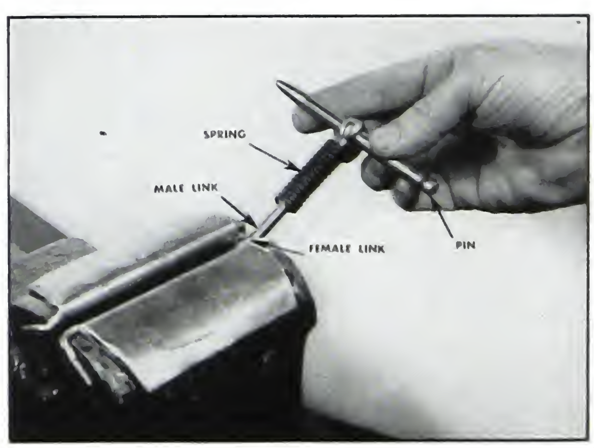


Fig. 5-225. Assembling over-run link

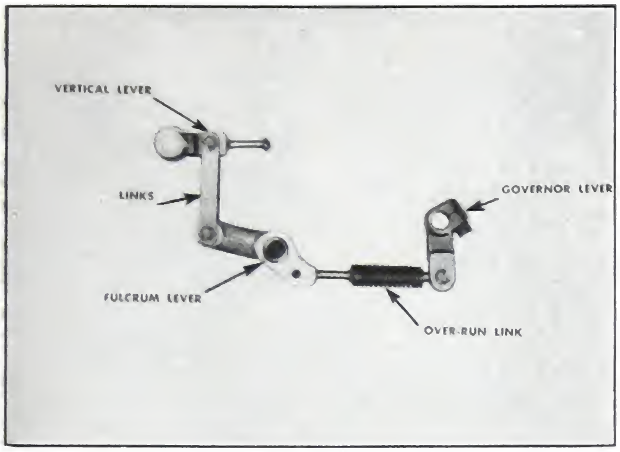


Fig. 5-226. Assembled linkage

GOVERNOR LEVER: Replace the link pin if brinelled or worn beyond .187 outside diameter. Governor lever should be replaced if link pin holes are worn beyond .189 inside diameter. Fig. 5-226.

ASSEMBLY OF LINKAGE: 1. Refer to Fig. 5-226. Lay the governor lever on a bench with the clamping screw to the left. Using the link pin and retaining ring, assemble the short end of the over-run link to the lever.

2. Assemble the fulcrum lever, using the short end, to the over-run link with the pin and retaining rings.

3. Using the pin and retaining rings, assemble the links to the fulcrum lever and the vertical lever.

4. Set eccentric so that it will hit against the maximum fuel stop. Fig. 5-227. Assemble the fulcrum to the eccentric with the fulcrum pin

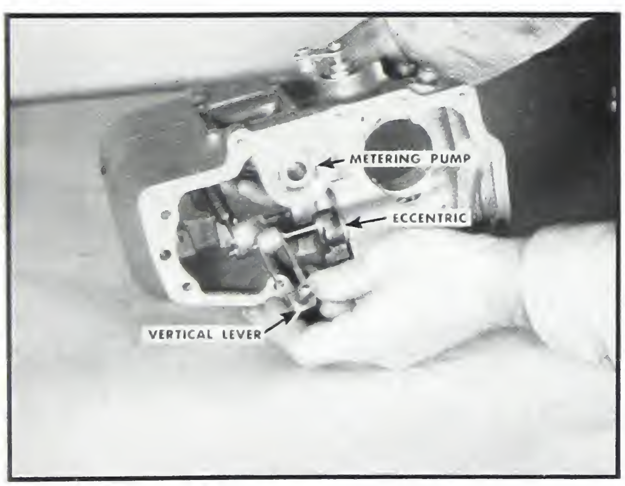


Fig. 5-227. Assembling linkage to eccentric shaft

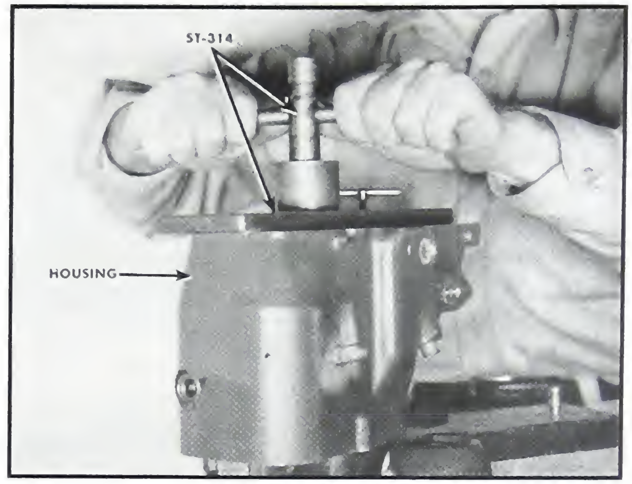


Fig. 5-228. Removing plunger barrel retainer

towards the governor housing. Insert the washer and retaining ring.

METERING PUMP: 1. Use spanner of ST-314 tool to unscrew the plunger barrel retainer nut. Fig. 5-228.

CAUTION: DO NOT CLAMP HOUSING IN A VISE.

2. Remove the retainer washer, plunger, barrel, spring and spring guide and plunger barrel sealing ring. Fig. 5-229.

3. Inspect the plunger and barrel for wear or score marks. A good test for the fit of the plunger is to close off one end of the barrel with a finger and test the suction. With both parts dry, suction should hold the weight of the plunger for at least one minute.

4. Assemble the copper sealing ring to the plunger barrel. Fig. 5-229.

5. Cover with lubricating oil and assemble the

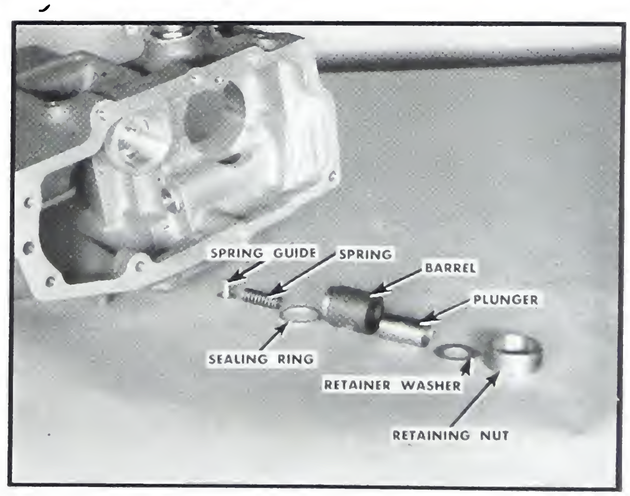


Fig. 5-229. Exploded view plunger and barrel assembly

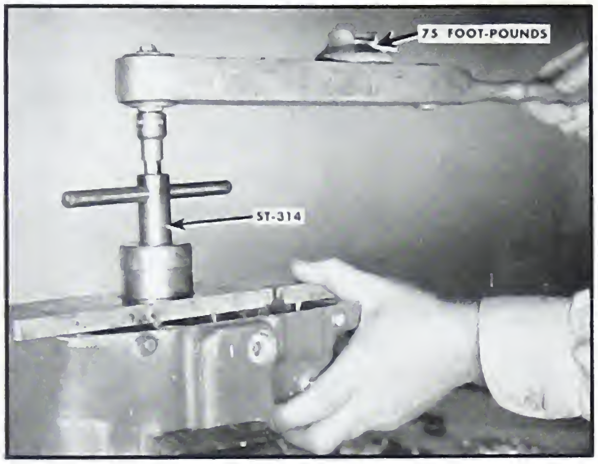


Fig. 5-230. Tightening retainer nut

barrel to the upper housing. Fig. 5-229. Install the spring guide, spring and plunger in the barrel.

6. Assemble retainer washer and nut.

7. Tighten retainer nut to 75 ft. lbs. torque with ST-314 fixture and a torque wrench. Fig. 5-230.

8. Using a drift pin through the inspection hole, work the oil into the plunger barrel until plunger works freely.

HAND CONTROL ECCENTRIC: 1. Remove the eccentric shaft locating screw.

2. Loosen the 1/4" socket head clamping screw, and remove the hand throttle control lever. Fig. 5-233.

3. Unscrew the two socket head screws and remove the outer hand control eccentric bushing. Remove eccentric shaft. Fig. 5-231.

4. Inspect the inner eccentric bushing. Replace new if worn beyond .628 inside diameter. When necessary, drive out the inner bushing with ST-359 and insert a new split bushing with ST-348. Fig. 5-232. Ream new bushing to .626/.627 inch with ST-350 piloted reamer.

5. Check the eccentric pin. Fig. 5-233. If eccentric pin is brinelled or worn beyond .374, the eccentric shaft assembly must be replaced. On pumps after Serial No. 22199 the pin can be replaced as a single part. These pins are held in place with an "E" ring. The pin is properly positioned when it protrudes from the shaft 1.077/1.082 inch.

6. Assemble a new rubber "O" seal ring to eccentric shaft and insert shaft in upper housing. Fig. 5-233.

7. With a new gasket, assemble eccentric shaft locating screw to upper housing. Point of locat-

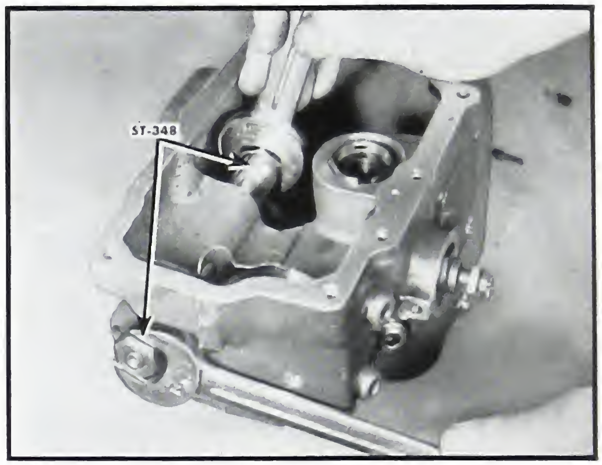


Fig. 5-232. Inserting new inner bushing

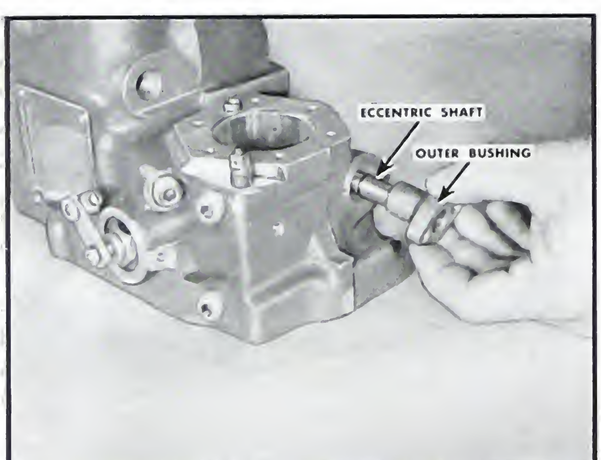


Fig. 5-231. Removing eccentric shaft

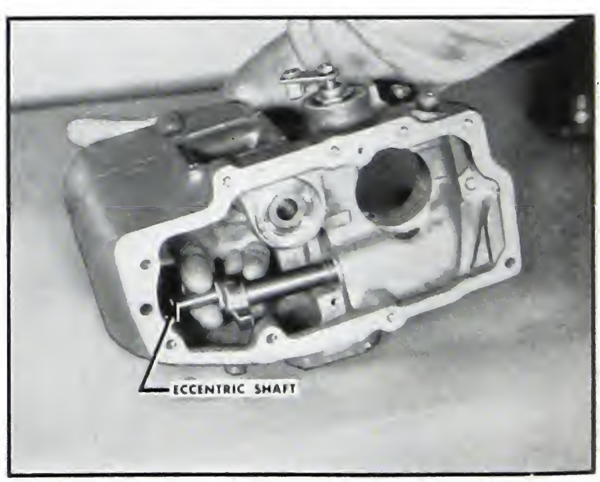


Fig. 5-233. Assembling eccentric shaft

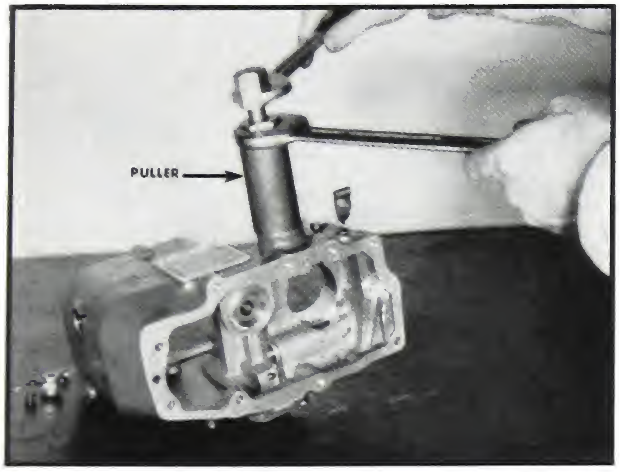


Fig. 5-234. Pulling emergency stop valve

ing screw fits 3/16" groove in eccentric shaft.

8. Check outer eccentric bushing. If worn larger than .502 inside diameter, replace with new bushing.

9. Assemble outer eccentric bushing to housing and secure with two No. 8—32 × ½" socket head capscrews and lockwashers. Fig. 5-231.

10. Assemble hand throttle lever to eccentric shaft. (See Page 5-106.) Secure socket head clamping screw. Be sure lever does not bind against outer eccentric bushing. Fig. 5-231.

Upper Housing Manual Emergency Shut-Off Valve

1. New parts are available for the shut-off valve, and if the valve housing is not damaged a new barrel assembly can be lapped in.

2. If the valve housing is damaged it can be replaced as an assembly. To replace, remove the nut, washer and lever assembly. Loosen the large retainer nut and pull the barrel assembly from the housing.

3. Pull the valve housing by using a hollow tube and capscrew which will fit the valve housing threads. Fig. 5-234.

4. The valve housing is a press fit in the upper pump housing, and the pump housing must be heated to replace the valve housing.

5. Heat the pump housing to 200° F., and with light blows, drive a new valve assembly in position. Fig. 5-235.

CAUTION: HOLES IN THE VALVE MUST ALIGN WITH FUEL PASSAGES IN THE PUMP HOUSING.

Main Housing

PRIMING VALVE: 1. Remove the priming valve. Fig. 5-236.

2. Replace the priming valve "O" ring and coat with Lubriplate or other high pressure lubricant. Fig. 5-236.

NOTE: Pumps before Serial No. 25369 have priming valves with metal seats. Inspect the priming valve seat. If chipped or broken out, it can be reseated by using a new standard No. F (.257) drill in a drill press. Only a light touch at high speed is necessary to "touch-up" the seat. On old style priming valves, with the acorn nut instead of a retainer nut, a 5/16" drill should be used to true up the valve seat.

AUTOMATIC EMERGENCY SHUT-OFF VALVE SEAT: 1. Check the emergency shut-off valve seat in the main housing after coating the

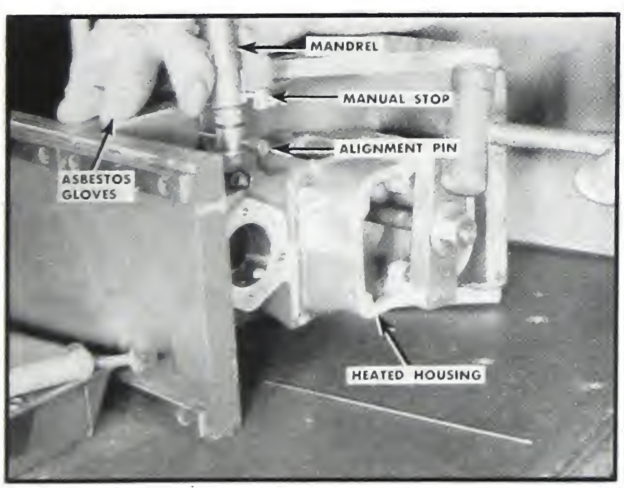


Fig. 5-235. Drive in new stop valve

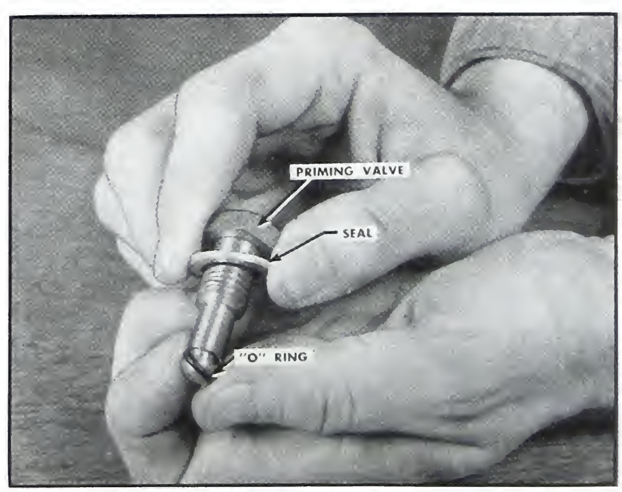


Fig. 5-236. Replace priming valve "O" ring

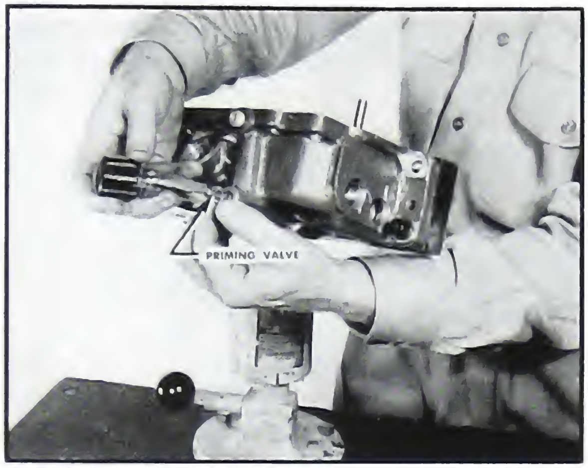


Fig. 5-237. Priming valve

valve with a light application of Prussian blue. Assemble shut-off assembly to main housing and trip. Seat will be indicated by a ring on the blued surface.

CAUTION: DO NOT ATTEMPT TO RESEAT THE VALVE UNLESS IT IS PROVED TO BE NECESSARY.

2. If valve does not seat, use ST-411 and take a very light cut. Fig. 5-247.

Cam Rocker Lever

ROCKER LEVER BRACKETS: 1. Inspect the bracket bushings for wear and out-of-round. If bracket bushing is worn larger than .8145, replace it with a new bracket assembly. Field replacement of these bushings is not recommended because the extreme close alignment tolerance

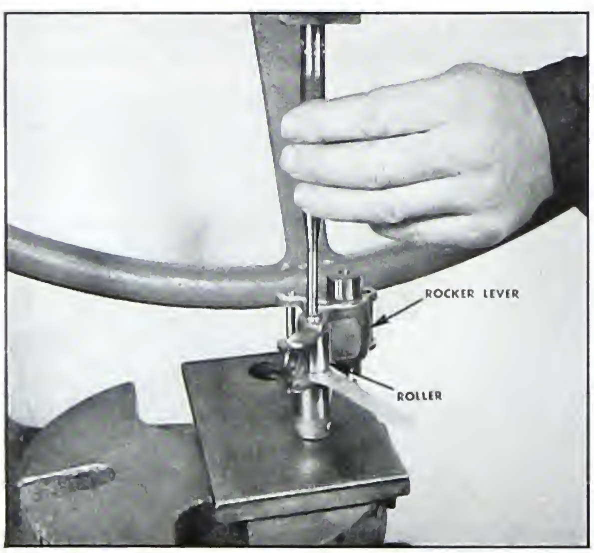


Fig. 5-238. Removing cam rocker lever roller pin

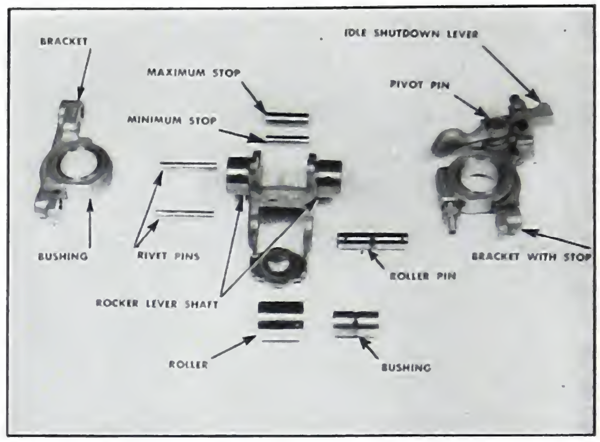


Fig. 5-239. Exploded view cam rocked lever assembly

requires special jigs and line-boring equipment. Fig. 5-239.

2. Check the wear of the idle shut-down lever on the pivot pin. If the lever has excessive (.004 to .006) clearance, the pivot pin should be pressed out of the bracket and the pivot pin and hole checked. Replace new if the pivot pin is worn smaller than .309 or if the pivot pin hole is larger than .315. Fig. 5-239.

3. To assemble the pivot pin and shutdown lever to the bracket, press the pivot pin in until the "E" ring can be assembled in its groove. The "E" ring must be assembled with open side down to prevent interference with the pump housing. See General Instructions at beginning of this section.

CAM ROCKER LEVER: 1. Check the cam rocker lever shaft and bushings for wear. Replace new if shaft is worn smaller than .8115 or if there is a total of more than .003 inch clearance between

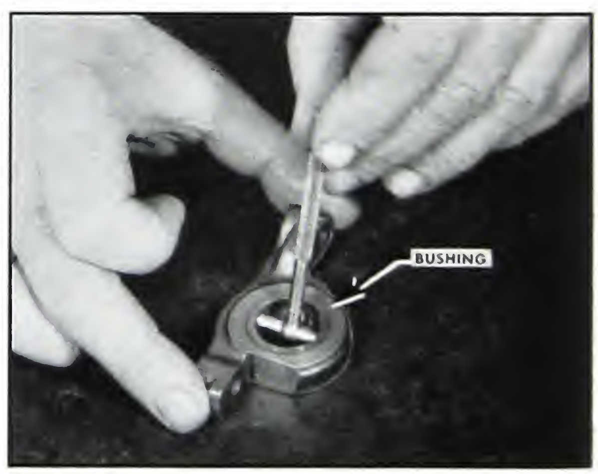


Fig. 5-240. Checking cam rocker bushings

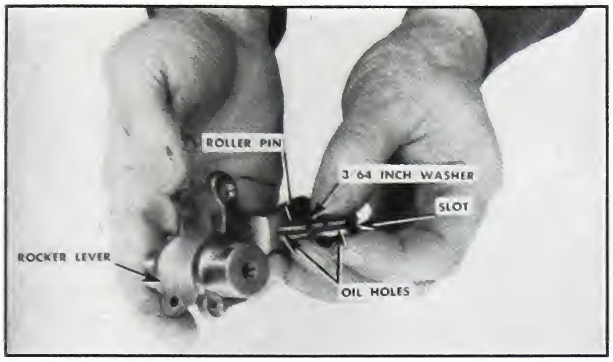


Fig. 5-241. Lining up oil holes

the shaft and bracket bushings. Fig. 5-239.

2. Excessive clearance between the shaft and bushings may cause loss in fuel pressure because of leakage at these points.

CAM ROCKER LEVER ROLLER: 1. Before removing the cam rocker lever roller, check the outer surface for wear or brinelling. Replace new if worn smaller than .748.

2. The cam rocker lever roller has a floating bushing: Compare its clearance with that of a new assembly. If it has more than .007 total clearance, it should be disassembled and each part should be checked for wear. See Fig. 5-239. Replace with new parts if worn beyond these limits:

Pin—.3640 O.D.
Bushing—.3665 I.D. and .5060 O.D.
Roller—.5095 I.D.

NOTE: Fuel pumps after Serial No. 17050 have a roller and pin only and alignment of oil holes is not required. Dimensions of these new parts are:

Pin—.3645/.3650 O.D.
Roller—.3665/.3675 I.D.

3. To assemble cam follower roller refer to "General Instructions for Pressing."

4. Scribe a mark on the cam rocker lever to locate the oil hole. Line up the oil hole of the pin with the scribed mark. With bushing and roller in place, press in the pin until the bottom of the slot is almost flush with the side of the rocker lever, or until the slotted end is 3/64" from the side of the lever. Fig. 5-241.

NOTE: A 3/64" thick washer over the pin and between the press and lever is handy to stop the pin at its proper position. Fig. 5-241.

5. Check lubricating passage with air hose. Slot in pin should line up with scribed mark on the lever. Fig. 5-241.

MAXIMUM AND MINIMUM FUEL STOPS: 1. Maximum or minimum fuel stops should not wear because stops normally do not contact the vertical lever. If wear is found, it is an indication of incorrect linkage adjustment. See "Adjustments". Page 5-108.

2. Maximum and minimum stop spacers are assembled to rocker lever with a 3/16" rivet pin.

CAM ROCKER LEVER SPRINGS: Check spring to following dimensions:

Free Length
1.60 in.
Load @ 1.208 in.
35.2 lbs. to 38.8 lbs.
Load @ 1.338 in.
23.5 lbs. to 25.9 lbs.

SHUT DOWN SPRING: Fig. 5-196.

Free Length
2 5/16 in.
Load @ 13/16 in.
30.4 lbs. to 33.6 lbs.
Load @ 1½ in.
48.4 lbs. to 53.6 lbs.

Manual Emergency Stop Lower Housing

The manual emergency stop described in succeeding paragraphs is BM-26677 which was released as a field replacement for the original lower housing DD manual emergency stops.

DISASSEMBLY: 1. Remove the plunger cap and lift out the spring and plunger. Fig. 5-244.

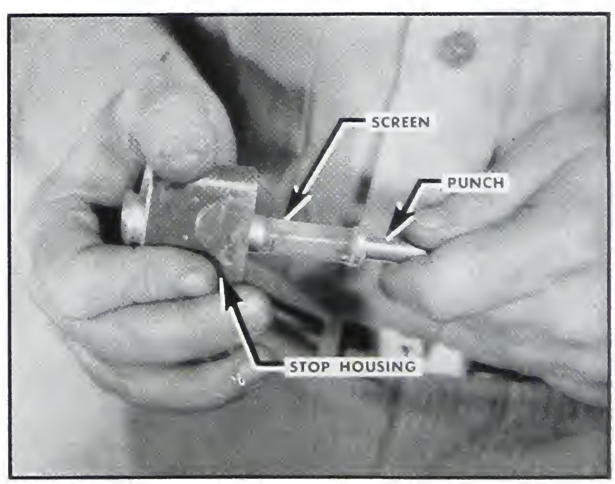


Fig. 5-242. Press in screen assembly

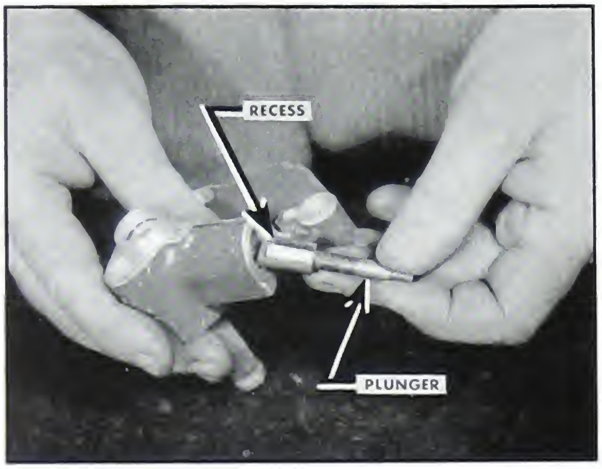


Fig. 5-243. Replacing the plunger

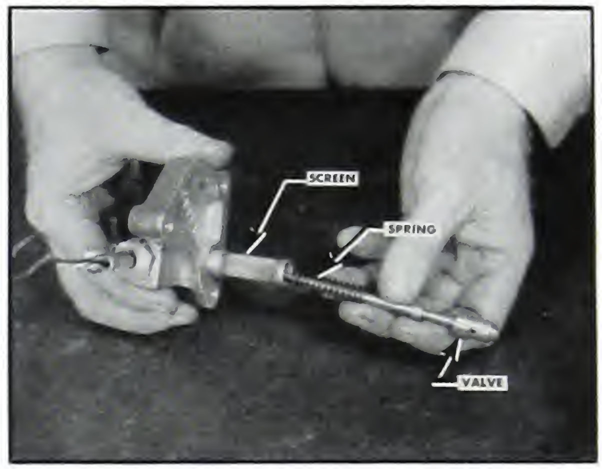


Fig. 5-245. Replace valve and spring

2. Disengage the rubber dust shield and remove the reset knob and valve catch.

3. Pull the valve assembly and spring from the housing and screen. The screen can be pressed out if damaged or if the "O" ring seal is leaking.

4. Inspect the "O" ring in the housing, replace if worn.

ASSEMBLY: 1. If the "O" ring in the housing requires replacement it can be inserted into the housing and guided into place by using a punch from the back side and pushing it in place from the front. Fig. 5-254.

2. If the screen needs replacement, assemble a new "O" ring around the screen, coat with Lubriplate nad press the screen assembly into the housing. Use a flat end punch against the base of the screen to press it in. Fig. 5-242.

3. Insert the plunger with the cut-out portion facing the reset knob side of the stop. Fig. 5-243.

4. Assemble the plunger cap, spring and cap washer to the stop housing. Fig. 5-244.

5. Insert a pull wire in the stem of the stop plunger and assemble the cable support in place.

6. Insert the valve and spring assembly. Fig. 5-245. Hold up the plunger to permit the valve stem to pass.

7. Screw the valve catch over the valve stem until 7/32 inch of the stem protrudes.

8. Screw on the reset knob and dust shield, and lock the knob against the catch. Seat the dust shield over the knob and housing. Fig. 5-246.

9. Valve travel is set after the stop is assembled to the pump. The travel for this manual stop should be set to the same limits and by the same method as the automatic stop described on Page 5-110.

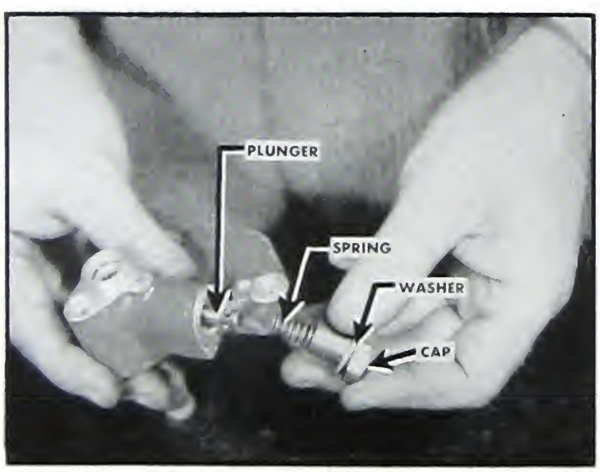


Fig. 5-244. Replace plunger cap

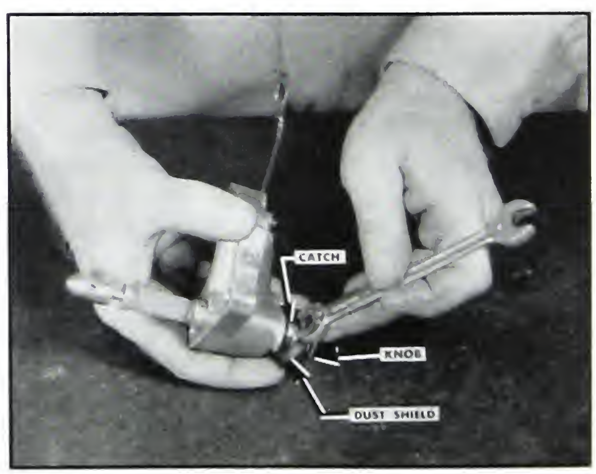


Fig. 5-246. Replacing knob and dust shield

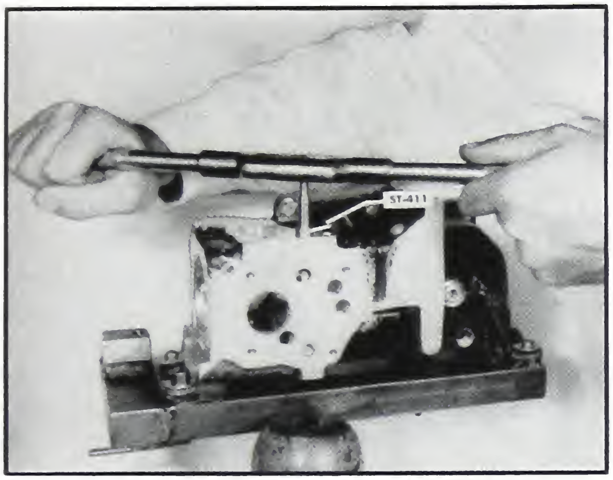


Fig. 5-247. Using ST-411

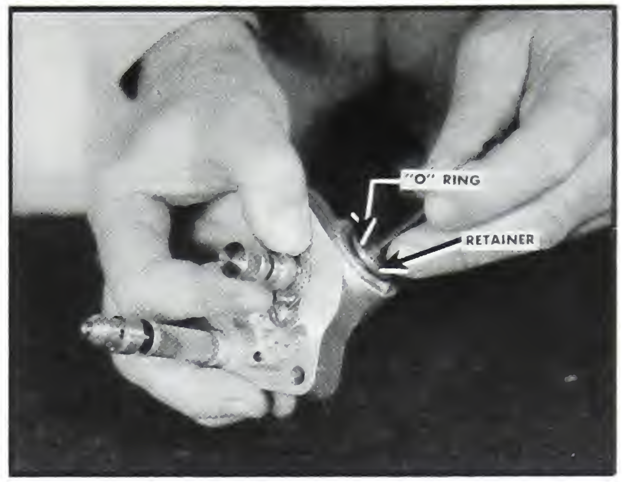


Fig. 5-249. Pulling "O" ring retainer

Automatic Emergency Stop

Two different automatic stops have been used on the DD Fuel Pump. If the pump has the old-style stop and it needs repair it must be replaced with the new style stop as described in following paragraphs. The new stop used in DD Fuel Pumps after Serial No. 17000 can be adapted to older pumps by reworking the stop bore with ST-411, see Fig. 5-247. The reworking dimensions are shown in Fig. 5-248. The following repair instructions apply to the latest stop.

DISASSEMBLY: 1. Remove the snap ring and pull the "O" ring retainer from the bore. The retainer is tapped so a capscrew can be used to pull it. Fig. 5-249.

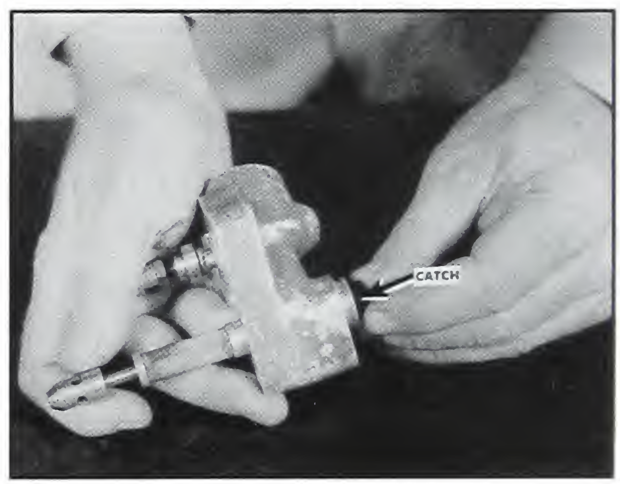


Fig. 5-250. Remove valve catch

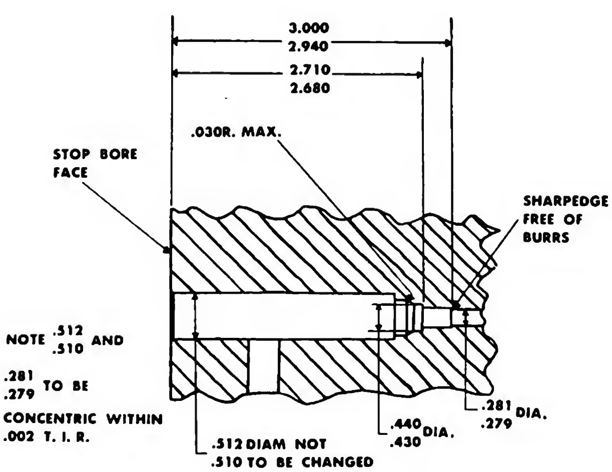


Fig. 5-248. Reworking dimensions to change pumps to latest automatic stop

Fig. 5-251. Remove trip assembly

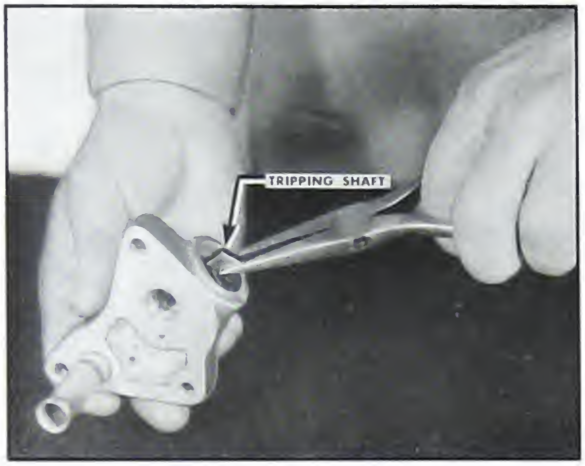


Fig. 5-252. Lift out tripping shaft

Fig. 5-254. Replacing "O" ring

2. Loosen and remove the reset knob and rubber dust shield.

3. Remove the valve catch and pull the valve assembly from the stop housing. Fig. 5-250.

4. Clip and remove the trip lock screw safety wire.

5. Remove the trip assembly. Fig. 5-251.

6. Pull out the reset spring and lift out the tripping shaft. Fig. 5-252.

7. Press out the valve screen assembly. Fig. 5-253.

8. Clean the screen assembly thoroughly and examine the "O" ring in the stop bore for wear. If any of the pump "O" rings are worn or damaged they must be replaced. It may be necessary to dress the valve stem with crocus cloth to remove burrs and provide free movement of the valve stem through the screen.

ASSEMBLY: 1. If it is necessary to replace the "O" ring in the stop housing it can be assembled easily by using a punch to keep the ring from going past the ring recess, and at the same time work it in with the end of another punch. Fig. 5-254.

2. If the stop has not been tripping properly, disassemble the trip assembly and check the spring and guide.

3. Replace the spring and plunger guide. Screw on the trip button and lock nut. Leave the button loose; its position will be determined later. Fig. 5-256.

4. Coat the "O" ring on the screen assembly with Lubriplate and push the assembly into the stop housing. Use a punch inside the screen and press against the retainer end to prevent damage to the screen from pressing. Fig. 5-257.

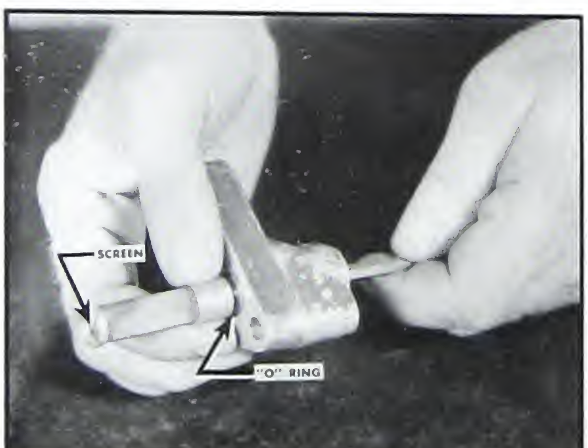


Fig. 5-253. Remove screen assembly

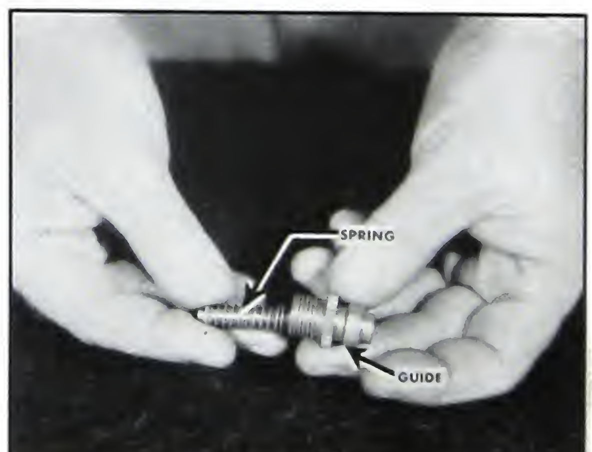


Fig. 5-255. Replace trip spring

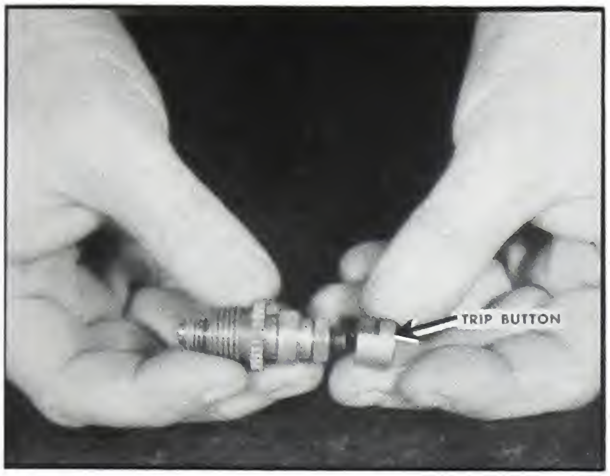


Fig. 5-256. Replace trip button

Fig. 5-257. Replace screen assembly

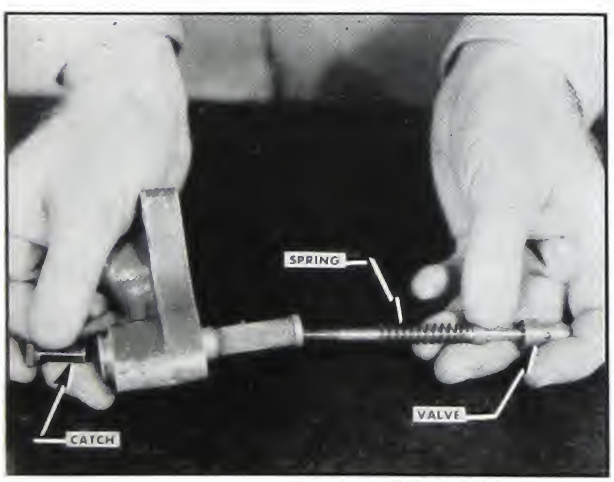


Fig. 5-258. Replace valve assembly

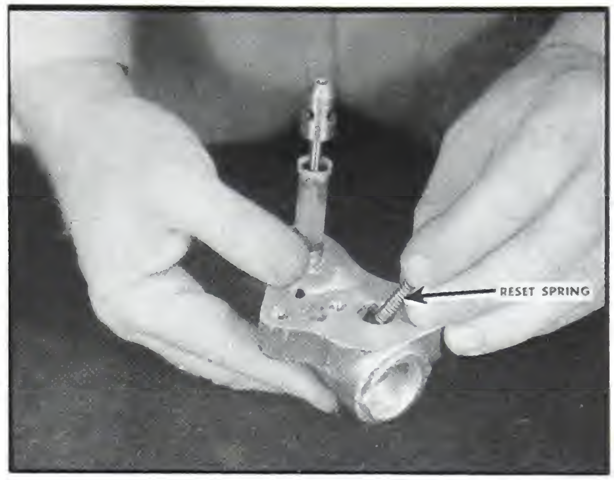


Fig. 5-259. Insert spring

5. Slide the valve spring over the valve stem and insert the valve catch through the housing "O" ring. Coat catch with oil or Lubriplate so it will slip through the "O" ring easily. Screw the valve into the catch until 7/32 inch protrudes from the catch. Fig. 5-258.

6. Insert the reset spring. Fig. 5-259.

7. Replace the tripping shaft by holding the valve assembly back so the shaft will engage the valve catch. Make sure the reset spring seats in the housing and shaft recesses. Fig. 5-260.

8. Screw the trip assembly into the housing and tighten securely. Lock assembly with the lock plate and screw. Fig. 5-261.

9. Wire the lock screw by passing safety wire through the screw hole and over the trip assembly. Fig. 5-262.

10. Replace the reset knob. Hold the catch in a position 7/32 inch from the end of the valve

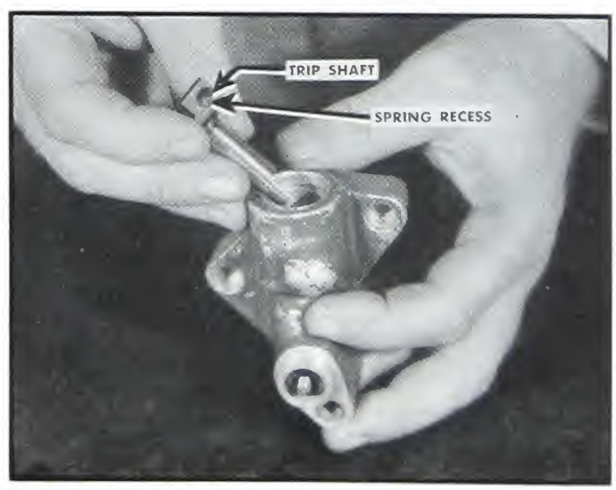


Fig. 5-260. Replace tripping shaft

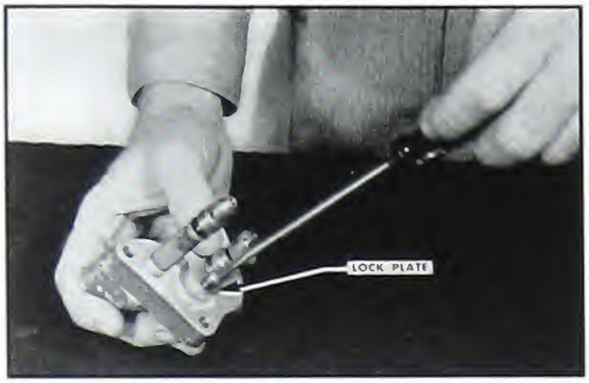


Fig. 5-261. Lock trip assembly

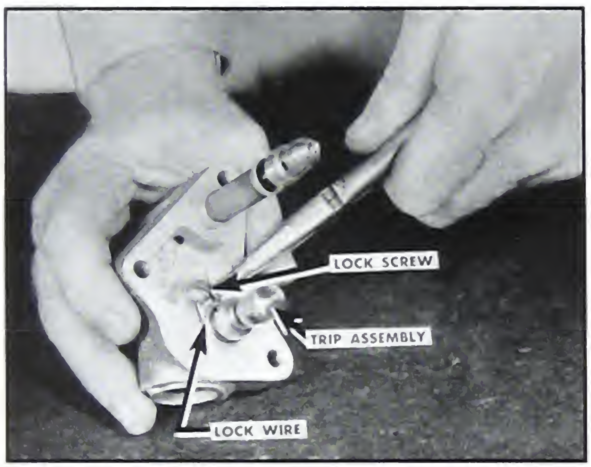


Fig. 5-262. Lock wire screw

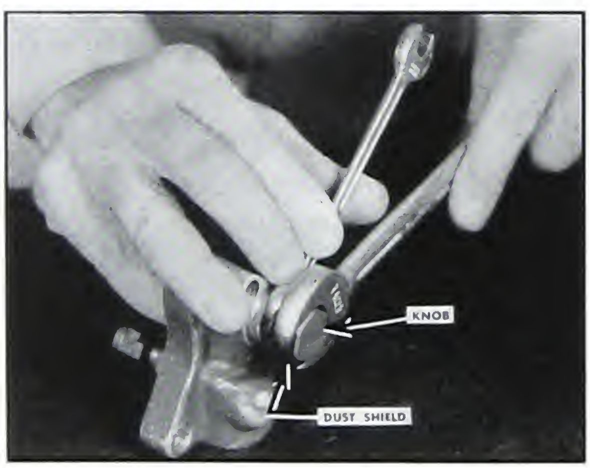


Fig. 5-263. Replace knob and shield

stem and screw on the knob and rubber dust shield. Fig. 5-263.

11. Push the retainer back into the plunger shaft bore and secure with a snap ring.

12. Adjust trip button as follows:

a. Check the distance from the face of the

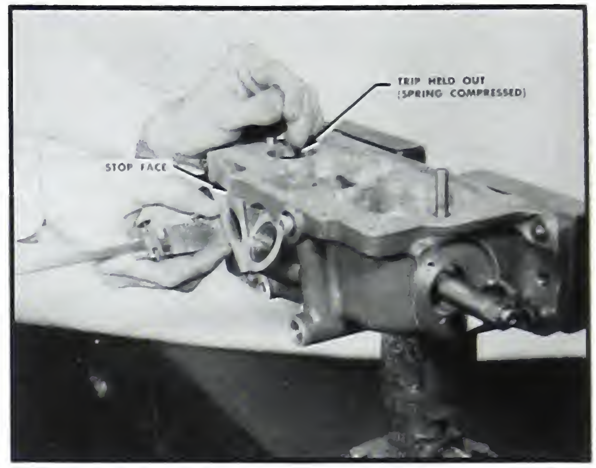


Fig. 5-264. Check housing to trip dimension

main housing to the overspeed trip button in the pump main shaft. Fig. 5-264.

CAUTION: THE TRIP BUTTON MUST BE HELD IN ITS OUT OR TRIP POSITION WITH THE SPRING FULLY COMPRESSED.

b. Add an additional .060 to this figure.

c. Check distance from stop gasket, with gasket in place, to the end of the trip button. Fig. 5-265.

d. The dimension in step "A" plus .060 in step "b" must equal dimension in step "c". If not, screw stop button in or out until they are equal then lock with the jam nut. Fig. 5-266. Check trip action on the test stand with stop assembled to lower housing before the pump is completely assembled.

AUTOMATIC OVERSPEED STOP WEIGHT: The overspeed stop weight rotates as a part of the camshaft and trips the automatic stop valve at a

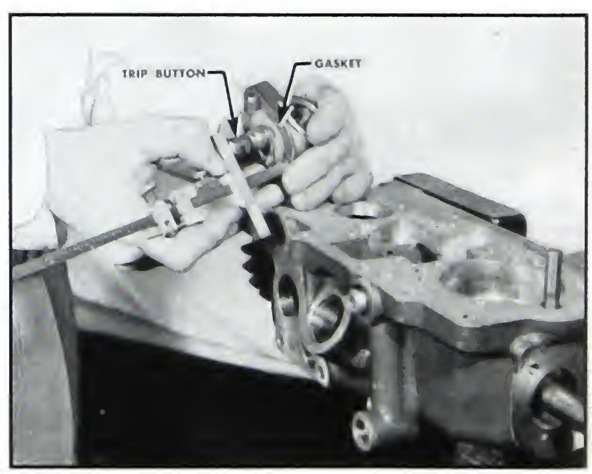


Fig. 5-265. Check stop gasket to button dimension

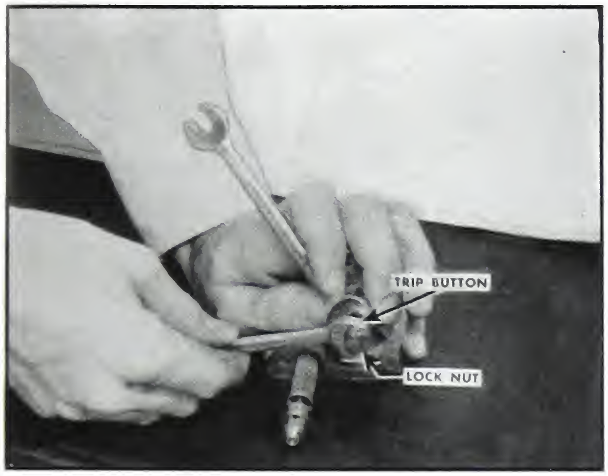


Fig. 5-266. Lock button

predetermined speed.

Should the overspeed stop weight need to be assembled or disassembled it can be done easiest while the camshaft is out of the pump. See Fig. 5-269. However, it can be assembled, disassembled or adjusted while the camshaft is in the pump by using ST-345 and ST-346 service tools.

1. ST-346 holding tool fits around and behind the camshaft to hold the weight during assembly, disassembly or adjustment. Fig. 5-270.

2. The three ST-345 tools telescope to give simultaneous adjustment to weight, retainer and locknut.

3. Overspeed stop weight is inserted through the side of the camshaft which has a relief in the weight recess. Fig. 5-269.

4. Spring, washer, spring retainer and locknut are assembled to the weight from the opposite side of the weight in that order. Fig. 5-269. See

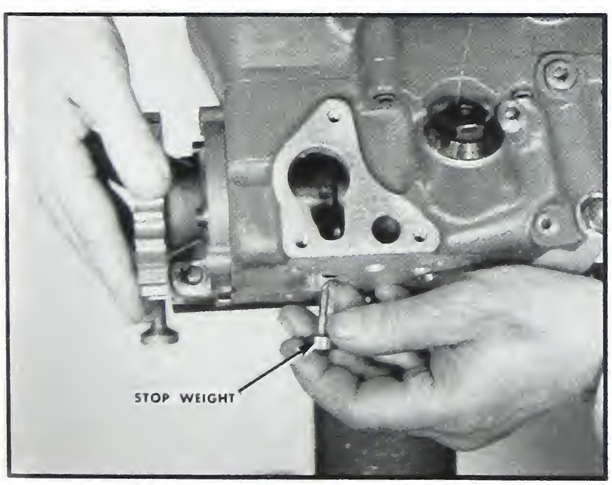


Fig. 5-267. Assemble stop weight

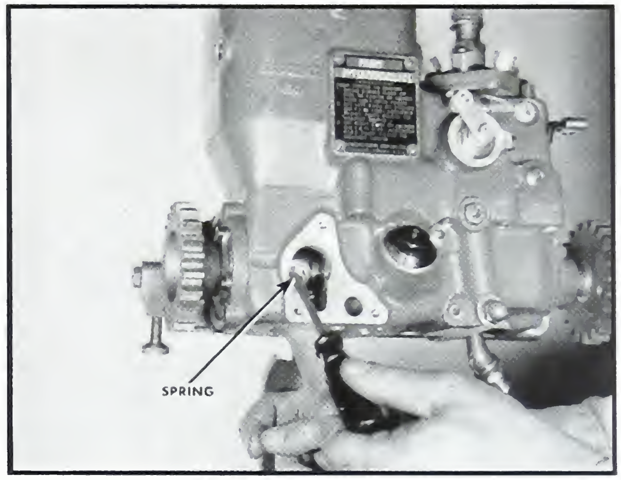


Fig. 5-268. Replace spring

also table of springs following:

Springs For Overspeed Stop Weight Assembly

Engine RPM	Tripping RPM	Part Number	Wire Diameter	Free Length
1200	1450	68451	.020	1.541
1550	1825	68656	.025	1.208
1800	2100	68651	.025	1.528
2100	2450	67788	.025	2.000

NOTE: Part No. 68098 overspeed weight is the same for all speeds.

5. Spring tension is predetermined approximately by screwing the retainer in until the face is flush with the threaded end of the weight.

Float Chamber And Gear Pump Assemblies

FLOAT CHAMBER AND BRACKET: 1. Remove the two socket head capscrews that hold the

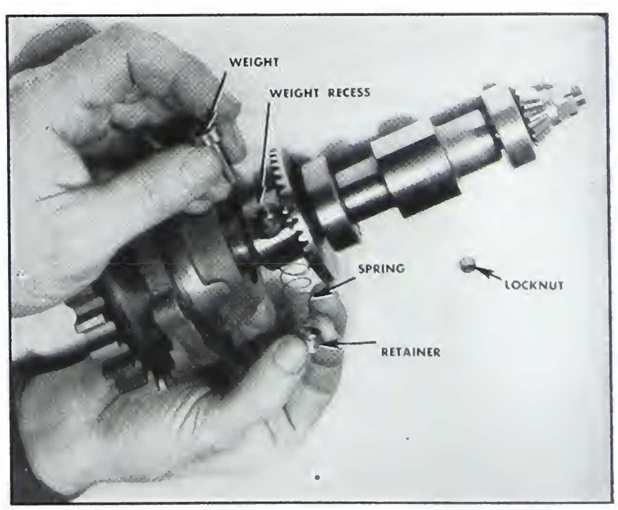


Fig. 5-269. Assembling weight with camshaft removed

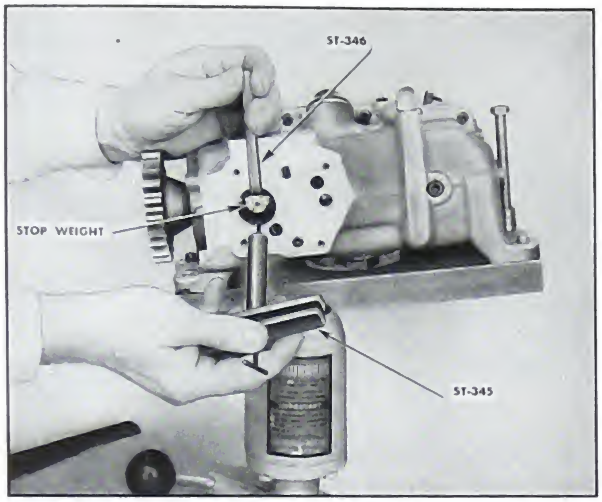


Fig. 5-270. Adjusting spring tension with weight assembled

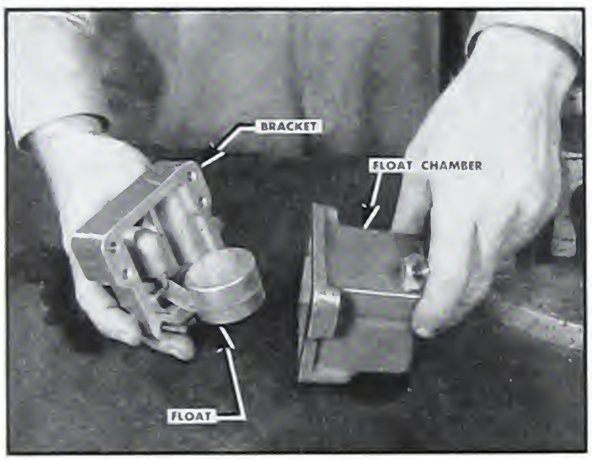


Fig. 5-271. Float chamber and bracket

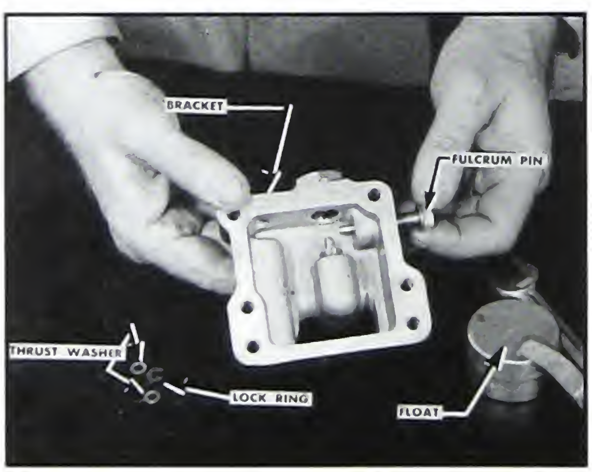


Fig. 5-272. Remove fulcrum pin

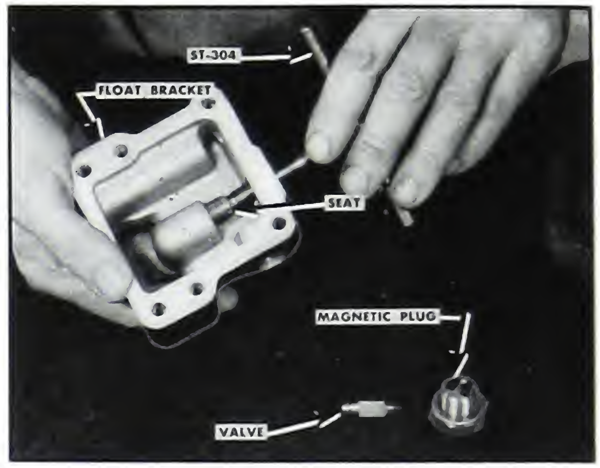


Fig. 5-273. Removing float valve seat

bracket to the float chamber. Fig. 5-271.

2. Pull the retaining ring and remove the washer from the fulcrum pin. Unscrew the fulcrum pin from the float bracket and remove the float. Fig. 5-272.

3. Unscrew the magnetic drain plug and lift out the float valve. Check the valve in the valve seat with Prussian blue.

4. If necessary, remove the float valve seat with ST-304 tool. Fig. 5-273.

5. Lap the valve into the seat using diamond dust or a fine lapping compound. Check again with Prussian blue for a full seat. Wash thoroughly to remove all lapping compound.

6. Use ST-304 and replace valve seat. Fig. 5-273.

7. Insert the float valve. Assemble the fulcrum pin to the float bracket.

8. Check the float for leaks.

9. Check the float and lever for angle of float.

Fig. 5-274. Setting float

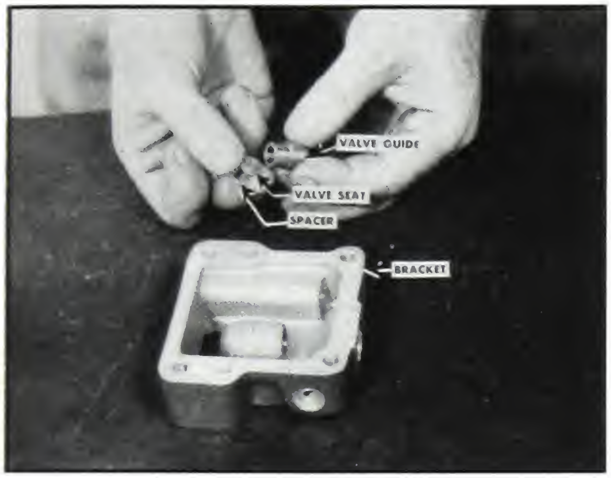


Fig. 5-275. Spacer to control float valve travel

Fig. 5-274.

10. Clean the magnetic plug. Using a new gasket, assemble the drain plug to the housing.

11. Replace the float lever over the fulcrum pin and secure with a washer and retaining ring.

12. Check the float valve travel. Valve travel should be between .030 and .035. Remove or add spacer washers under valve seat to adjust travel. Fig. 5-275.

13. With a new gasket, assemble the bracket to the float chamber with two $\frac{1}{4}$—20 x $1\frac{3}{4}''$ socket head capscrews, flat washers and lockwashers. Fig. 5-271.

14. Check to see that the float does not hit either the top or bottom of the float chamber when assembled. There should be approximately $\frac{1}{8}$ inch clearance at top. Fig. 5-276. As shown in Fig. 5-276, the top of the float chamber is at the finger tips.

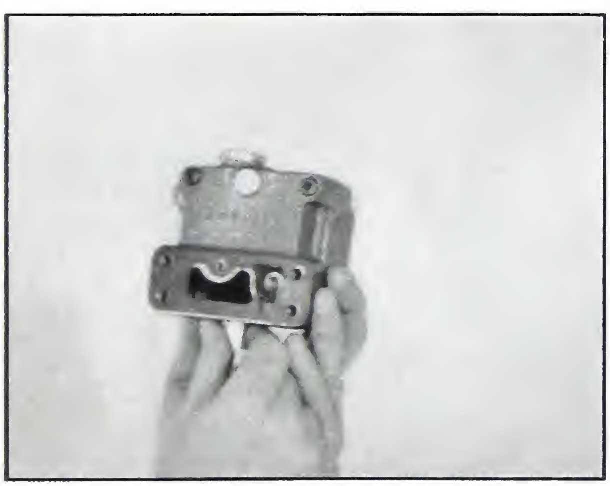


Fig. 5-276. Check float for clearance

INLET CONNECTION AND INLET CHECK BALL: 1. Unscrew the one-inch hex head of the check ball seat and remove inlet connection from No. 1 gear pump cover.

2. Clamp the check ball seat in a copper jawed vise and remove the retainer ring. Fig. 5-277. Inspect the check ball and seat.

3. Use a light hammer and a brass drift to reseat the 13/32" check ball. Fig. 5-278.

4. Assemble the check ball to the seat and secure with snap ring. Fig. 5-279.

5. Using two new gaskets, assemble the inlet connection, and tighten securely to No. 1 housing. Refer to Fig. 5-299.

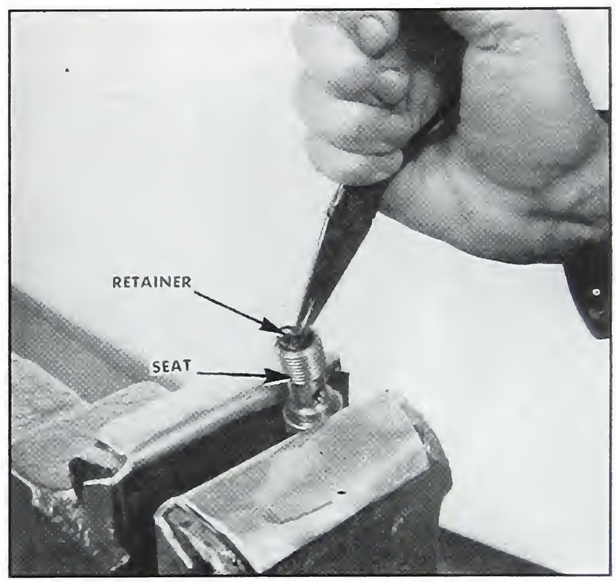


Fig. 5-277. Removing check ball retainer

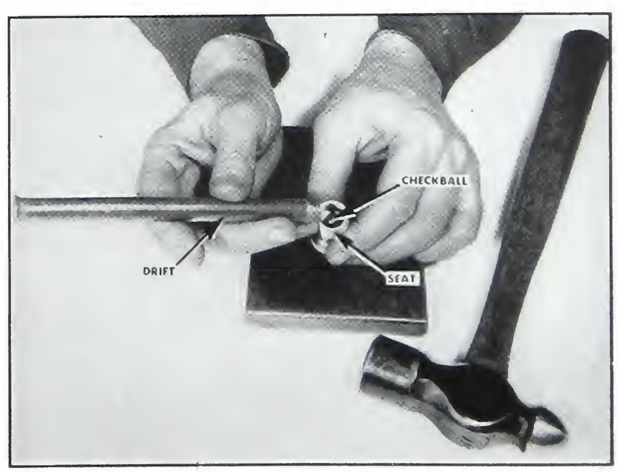


Fig. 5-278. Seating check ball

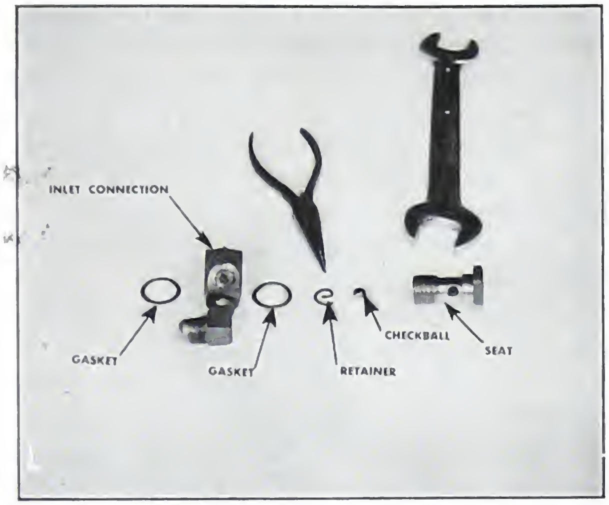


Fig. 5-279. Exploded view of check ball assembly

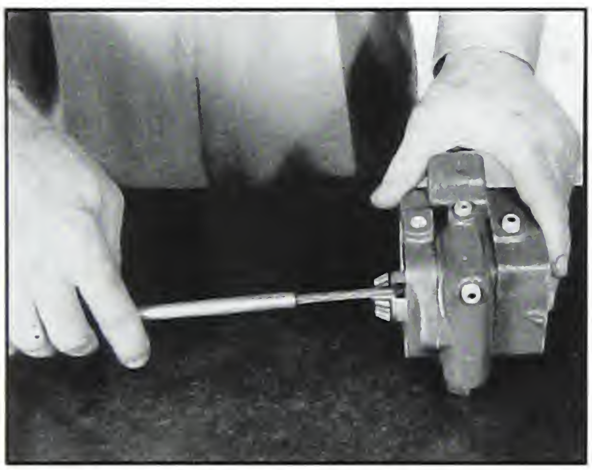


Fig. 5-280. Remove No. 2 cover capscrews

Fig. 5-281. Remove No. 1 drive gear

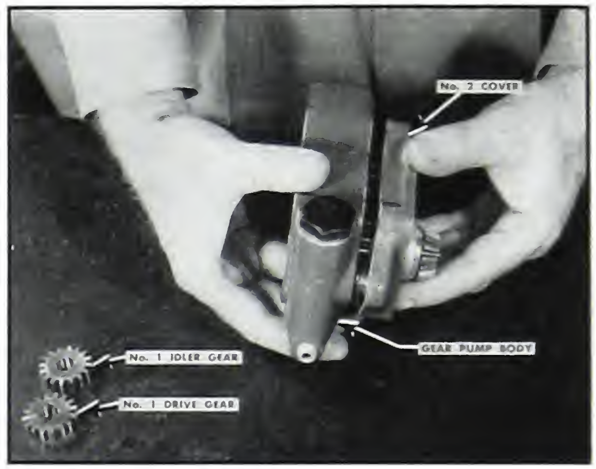


Fig. 5-282. Disassemble No. 2 cover and pump body

GEAR PUMPS: *Disassembly:* 1. Remove two 1/4 inch socket head screws from the No. 2 cover and pull off the No. 1 cover. It may be necessary to tap lightly with a plastic hammer to loosen. Fig. 5-280.

2. Remove No. 1 drive gear and idler gear and place on clean paper or cloth in a position to identify them for replacing in the same position as when removed from the pump body. This is to preserve original wear pattern. Fig. 5-281.

3. Pull out the gear drive pin and pull the No. 2 cover from the gear pump body. Fig. 5-282.

4. Lift the idler shaft and No. 2 idler gear from the main body as the No. 2 cover.

5. Pull the No. 2 drive gear from the gear pump drive shaft. Fig. 5-283.

6. Remove the No. 2 drive gear key. Fig. 5-284.

7. Press the drive shaft from the drive gear and No. 2 gear pump cover. Fig. 5-285.

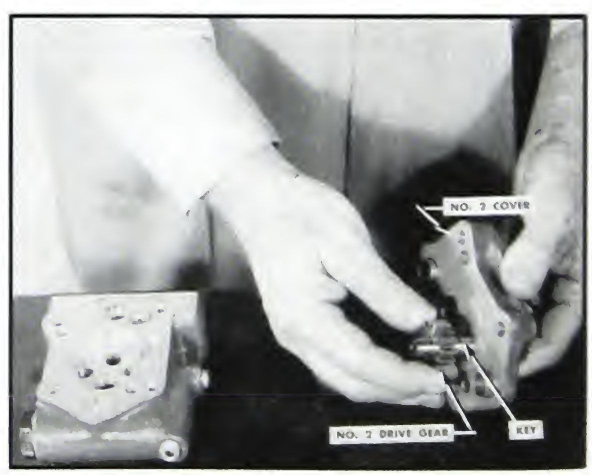


Fig. 5-283. Pull No. 2 drive gear

Fig. 5-284. Pull drive key

8. Remove the snap ring from the No. 2 cover and take out the drive shaft bearing. On latest pumps this bearing has been replaced with a thrust type bushing. Fig. 5-291. If this bushing is damaged it must be replaced with a new No. 2 cover as an assembly.

INSPECTION OF GEARS, GEAR POCKETS AND SHAFTS: 1. If the gear pockets are scored, the gear pump housing must be replaced.

2. To check gear pocket depth use a depth micrometer then check thickness of gears and subtract. If the clearance is greater than .0015 on No. 2 side or .002 on No. 1 side replace the housing. Fig. 5-284 and 5-287.

3. No. 2 gears should not be used with new housing if worn thinner than .389. Fig. 5-287.

4. No. 1 gears should not be used with a new housing if worn thinner than .2587.

5. Inspect shafts for brinelling or roughness.

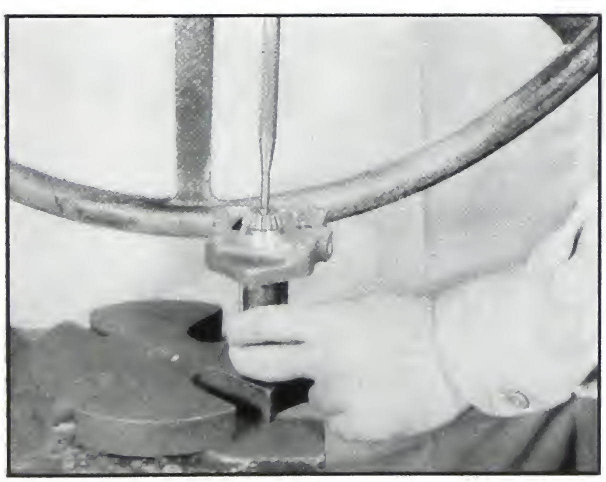


Fig. 5-285. Press out drive shaft

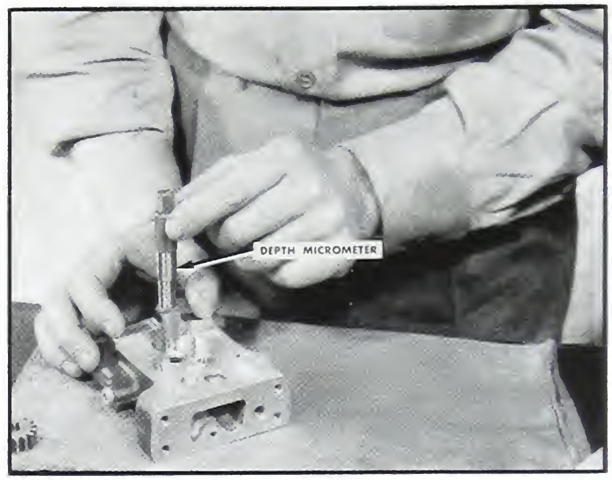


Fig. 5-286. Checking gear pocket depth

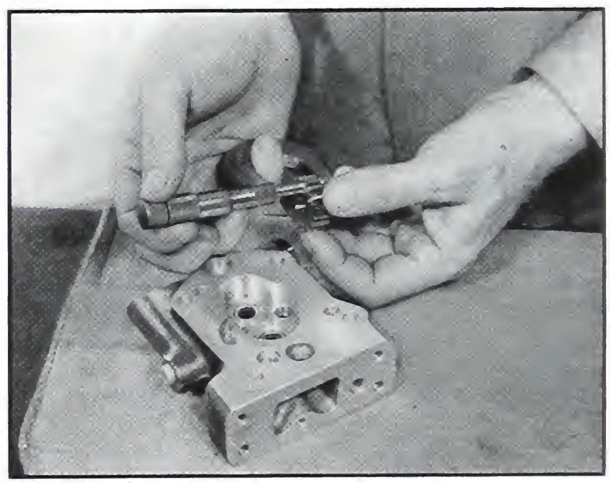


Fig. 5-287. Checking gear thickness

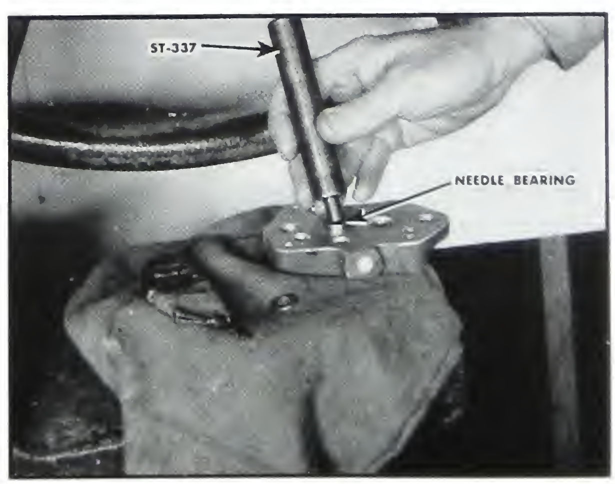


Fig. 5-288. Press in new gear pump needle bearing

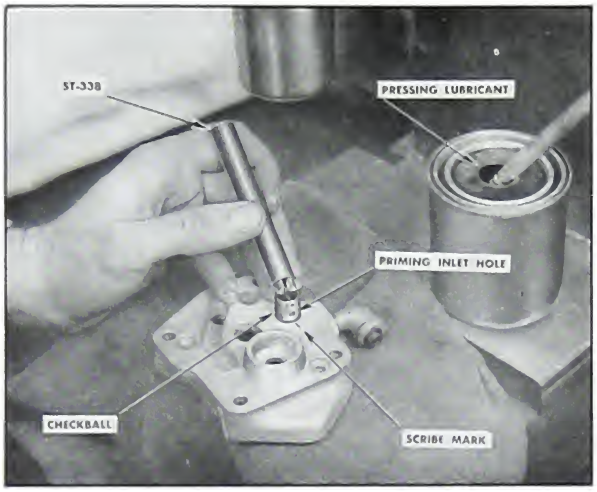


Fig. 5-289. Replace No. 2 check ball

If shaft is brinelled, the needle bearing will usually need replacing also. Use new shafts if old shaft is worn smaller than .374.

NO. 2 COVER: 1. Clean and inspect No. 2 cover ball bearing; replace if worn, or if it has rough races or cracked balls.

2. Replace needle bearings as needed by pressing in with ST-337 mandrel. Use .015 spacer on ST-337 mandrel to provide space for seals. Fig. 5-288.

3. If No. 2 check ball is not seating, rusty, or sticking, press out the ball and seat assembly with ST-307 mandrel.

4. Before assembling the check ball to the No. 2 cover, make a pencil mark to locate the position of priming inlet hole. Use ST-338 mandrel press in until snug against bottom of No. 2 cover. Check to see that the priming inlet is open. Fig. 5-289.

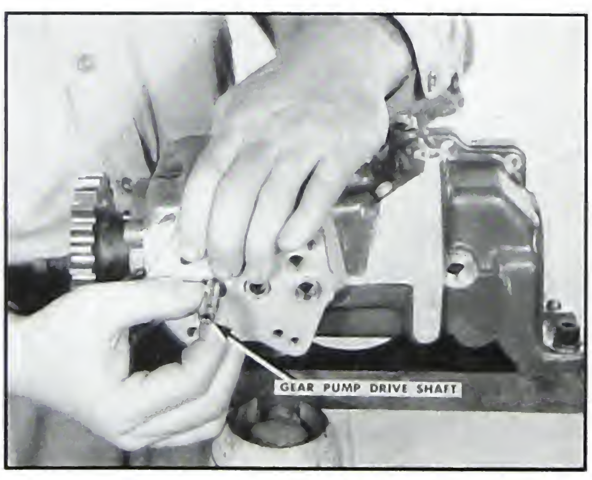


Fig. 5-290. Check back lash

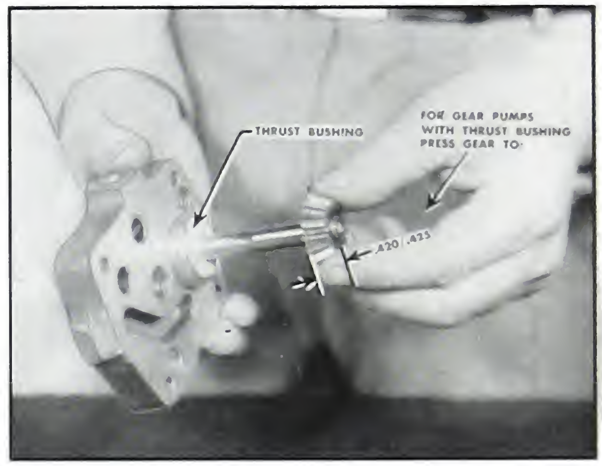


Fig. 5-291. Replacing drive shaft assembly

5. If No. 2 cover ball bearing has been removed, assemble a new unit to the gear pump driving shaft and press into cover with ST-339 mandrel.

6. Assemble snap ring to the housing to secure the ball bearing. Replace any spacers removed and press on the gear pump driving gear. Assemble cover and drive shaft assembly to main housing and check back lash. Fig. 5-290. Back lash should be .005/.004. Add additional spacers if required. Pull out on shaft while checking.

GEAR PUMPS WITH THRUST BUSHING: 1. Press the drive gear on the drive shaft until the distance from the back of the gear to the end of the shaft is .420/.425. Fig. 5-291.

2. Back lash on this type gear pump should be .002 to .004, and it can be obtained by use of gaskets between the gear pump and fuel pump main housing. Pull out on shaft while checking.

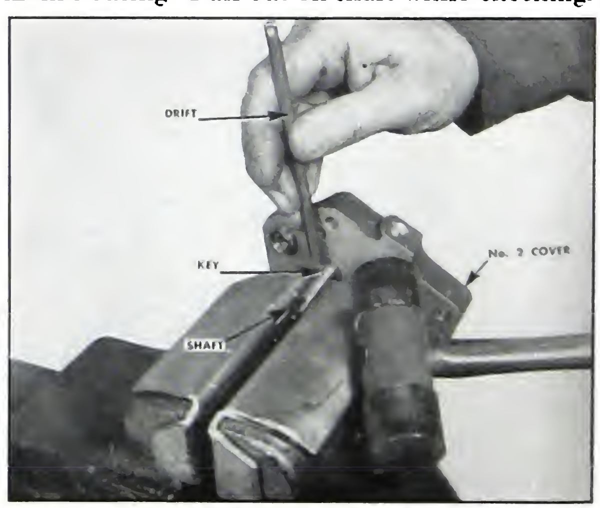


Fig. 5-292. Assemble key to drive shaft

Fig. 5-293. Remove No. 1 by-pass valve

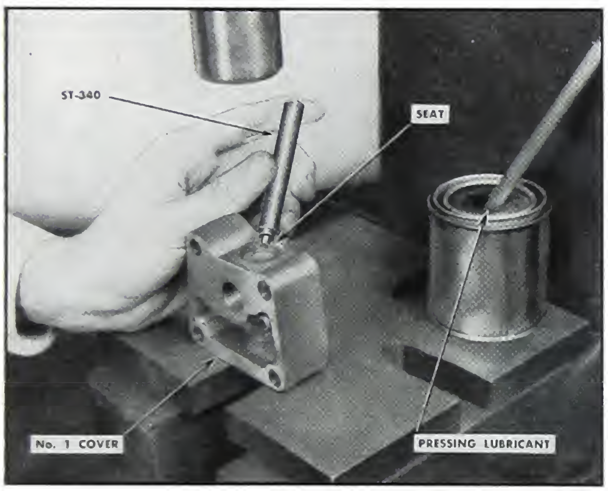


Fig. 5-294. Replace No. 1 by-pass valve seat

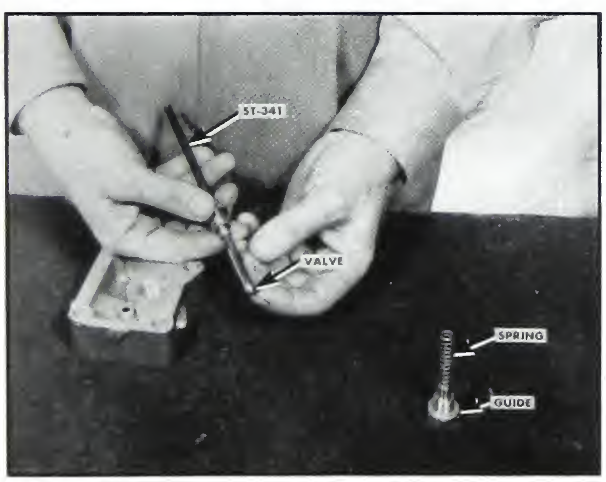


Fig. 5-295. Seat No. 1 by-pass valve

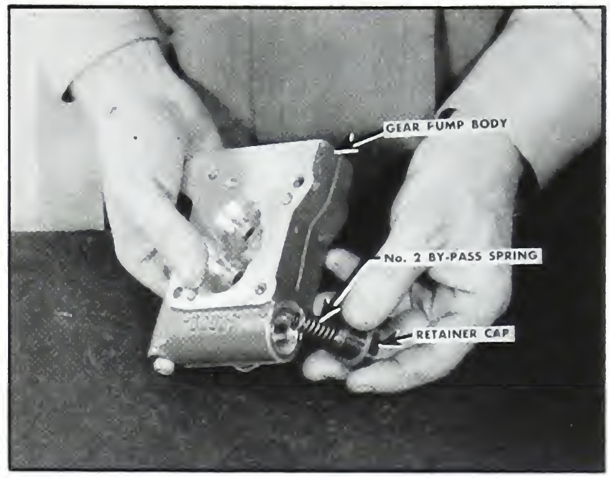


Fig. 5-296. Assembling No. 2 by-pass valve

NO. 1 BY-PASS VALVE AND SEAT: 1. Unscrew the ¾" hex head of the by-pass valve guide. Remove guide, spring and valve. Fig. 5-293.

2. Inspect the seat: If worn or chipped, press out with ST-355 and replace using ST-340 mandrel. Fig. 5-294.

3. Inspect the valve: Replace if worn or scored. Use ST-341 seating tool to guide and seat the valve. A light tap with a plastic hammer is sufficient. Fig. 5-295.

4. Using a new gasket, assemble valve, spring and guide to No. 1 gear pump cover.

NO. 2 BY-PASS VALVE: 1. Unscrew the one-inch hex spring retainer and remove the gasket, spacers, spring and valve. Fig. 5-296.

2. If the valve is scored or sticking, it can be dressed down lightly with crocus cloth or replaced with a new valve.

3. Normally, the valve sleeve will outwear the gear pockets of the housing and will be replaced as a complete assembly.

4. Check spring dimension on standard spring tested according to following dimensions:

Free Length	Load @ 1.312"	Load @ 1.209"
1.392	5.7 to 6.3 lbs.	13.0 to 14.4 lbs.

5. Install valve and spring with heavy coil end of spring and approximately five spacers in the retainer cap. Secure retainer. Fig. 5-296.

ASSEMBLING GEAR PUMP: 1. Assemble a new No. 2 gear pump gasket to the No. 2 cover with No. 3 Permatex. Apply Permatex thinned with alcohol to the gasket but do not allow this to get

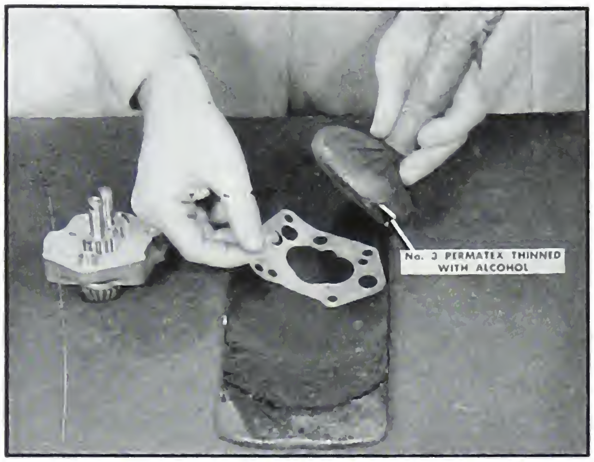


Fig. 5-297. Coat gasket with Permatex

into gear pockets. Fig. 5-297.

2. Replace No. 2 drive gear over drive shaft and key. Assemble No. 2 idler gear and shaft. A rubber seal is used next to the needle bearings or thrust bearing followed by a convex washer. Assemble washer with convex side up or toward the gears.

3. Coat gear pockets with Lubriplate.

4. Assemble convex washers over gear shafts, follow with rubber seals and assemble main body to No. 2 cover. Fig. 5-298.

5. Replace No. 1 drive gear key and the idler and drive gears. Fig. 5-299.

6. Coat No. 1 gasket as in Step 1 and assemble No. 1 cover to gear pump. Fig. 5-300. Always use flat steel washers next to aluminum.

7. Assemble the float chamber and inlet connection on the gear pumps. Fig. 5-301.

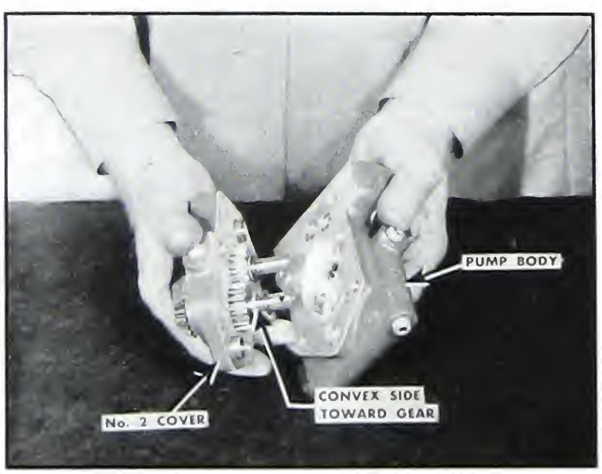


Fig. 5-298. Replace main body

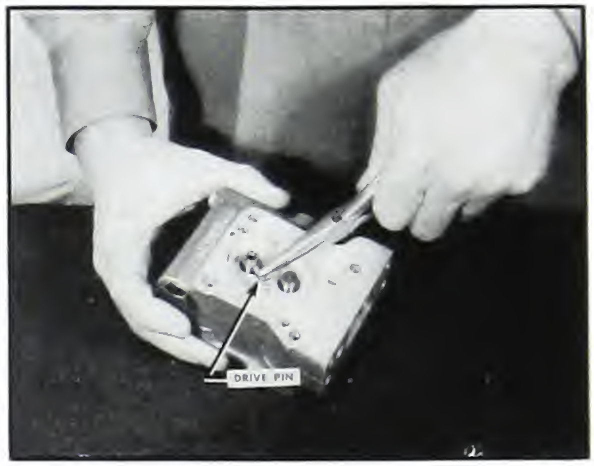


Fig. 5-299. Replace drive pin

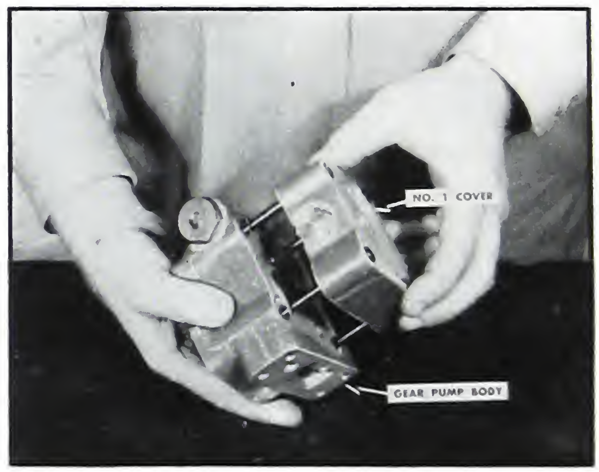


Fig. 5-300. Replace No. 1 cover

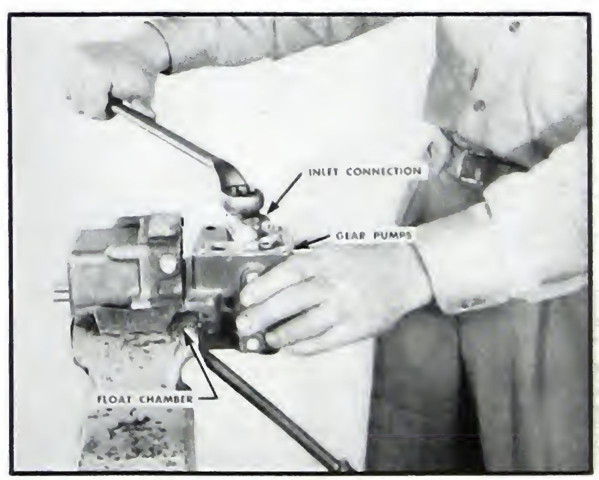


Fig. 5-301. Replace inlet connection

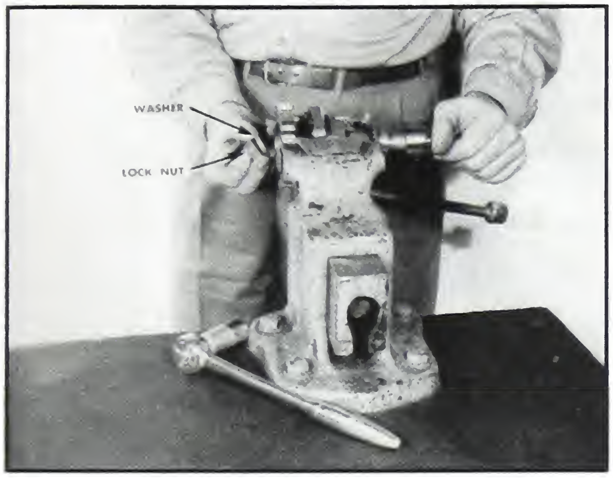


Fig. 5-302. Removing drive coupling locknut

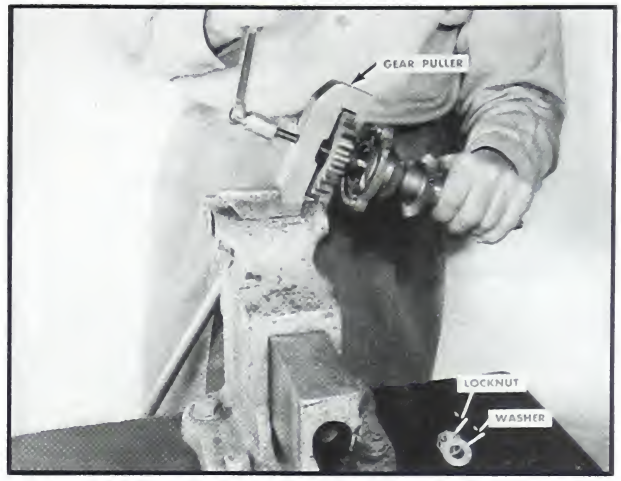


Fig. 5-304. Pull drive coupling

Main Or Camshaft

CLEANING AND INSPECTION: 1. Clean and inspect camshaft before any further disassembly. Remove only the necessary parts.

2. Check the gears and cam lobes for wear, score marks, and scuffing. Any light score marks on the cam lobes usually can be polished off with crocus cloth. Fig. 5-303.

3. If bevel gears need replacing, their matching gears should also be replaced. New and worn gears should never be run together.

4. Ball bearings should be replaced if rough or if races are worn enough to detect any shake.

DISASSEMBLY: 1. Remove the drive coupling lock nut and pull or press off the drive coupling. Fig. 5-304.

2. Using parallels and an arbor press, press off the front bearing support. Support is tapped with two ¼"-20 holes to adapt pullers.

3. Using an abor press and suitable mandrels, press off the governor-gear pump drive gear. Fig. 5-305.

4. To replace the middle ball bearing, remove both the coupling and drive gear keys and press off in an arbor press.

5. To replace the rear ball bearing, press off with arbor press. Fig. 5-306.

ASSEMBLY (See General Pressing Instructions): 1. Using ST-320 and ST-321 tools, press on middle ball bearing. Fig. 5-307.

2. With ST-320 and ST-321 tools, press on rear ball bearing.

3. Assemble the disc drive gear to the tapered end of camshaft with washer and locknut. Torque nut to 45 ft. lbs. Fig. 5-308.

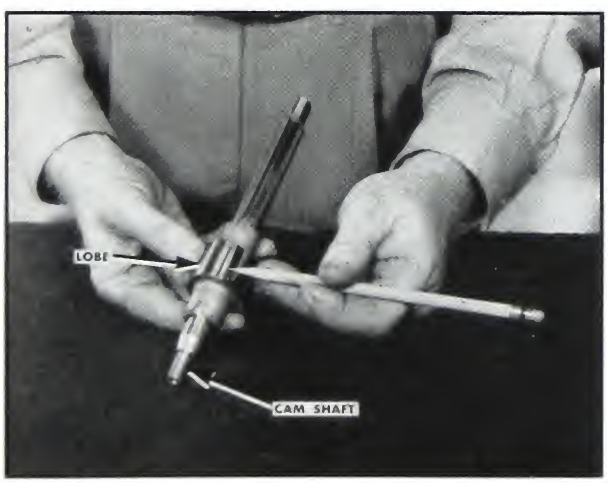


Fig. 5-303. Checking cam lobes

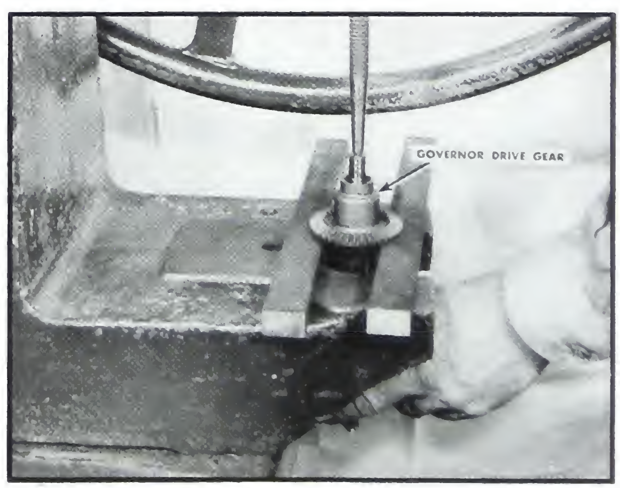


Fig. 5-305. Removing governor-gear pump drive gear

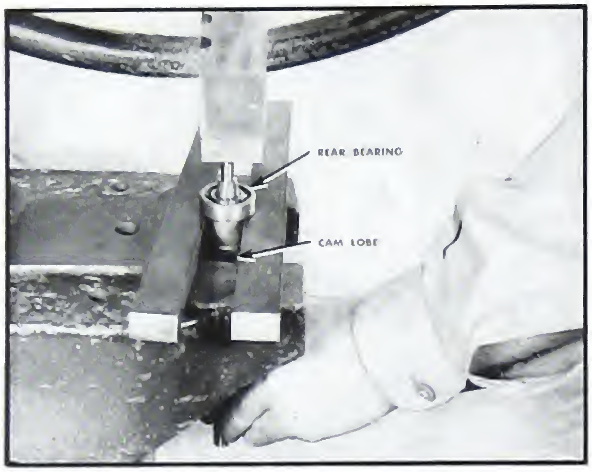


Fig. 5-306. Removing rear ball bearing

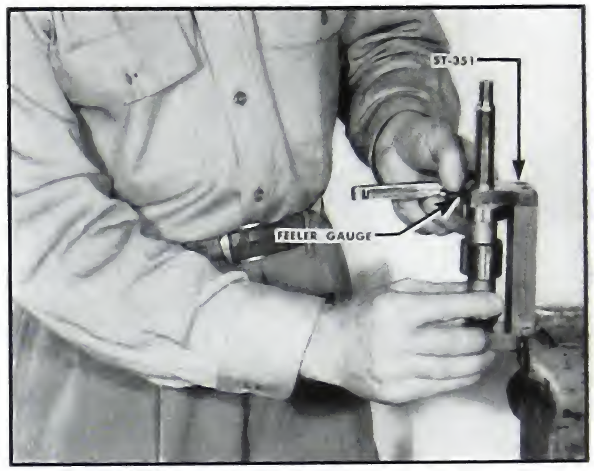


Fig. 5-309. Check spacing with ST-351

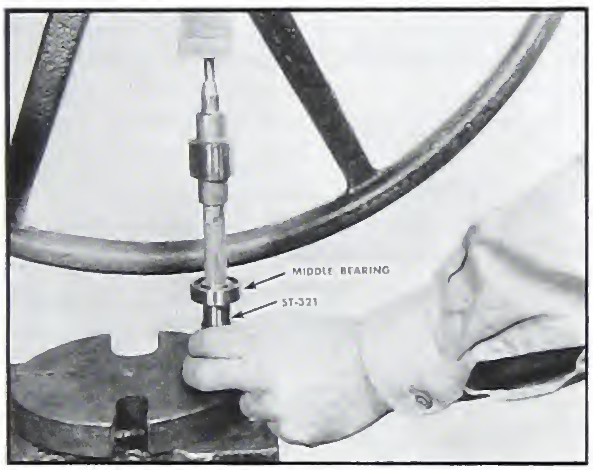


Fig. 5-307. Assembling middle ball bearing

4. Check spacing between the small diameter of the disc driving gear and the inner race of the middle ball bearing. Correct spacing is 4.029 inches. Use ST-351 snap gauge and add spacers as needed to get correct spacing. Fig. 5-309.

5. Insert the governor-gear pump drive gear key, and press the governor-gear pump drive gear on the camshaft. Fig. 5-310. For right-hand pumps, the governor-gear pump drive gear must be assembled so that the teeth face the front of the pump. For left hand pumps the teeth must face towards the cam lobes.

6. If used assemble the automatic overspeed stop weight to the camshaft. (See Emergency Stop Instructions.)

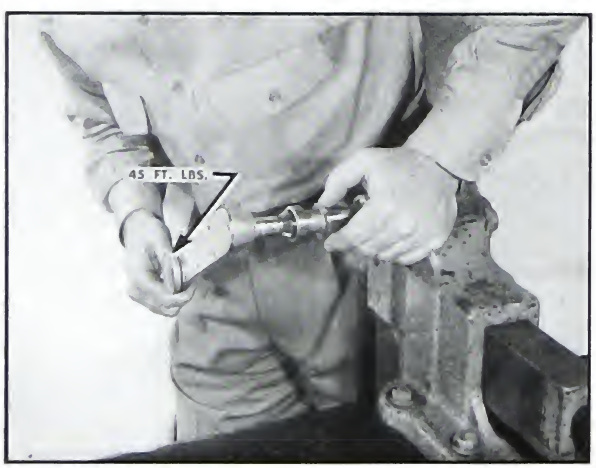


Fig. 5-308. Torque distributor drive gear nut

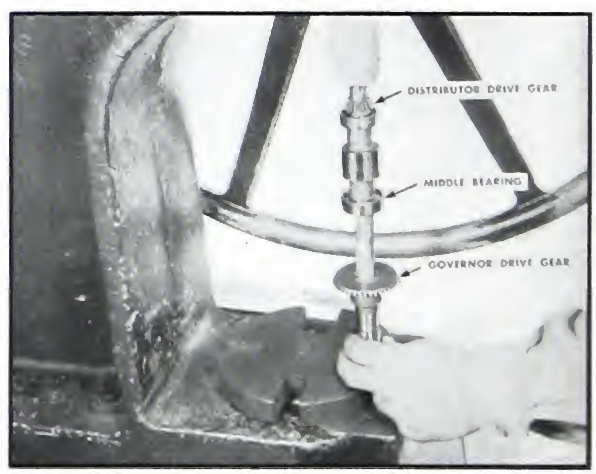


Fig. 5-310. Assembling governor gear pump drive gear to camshaft

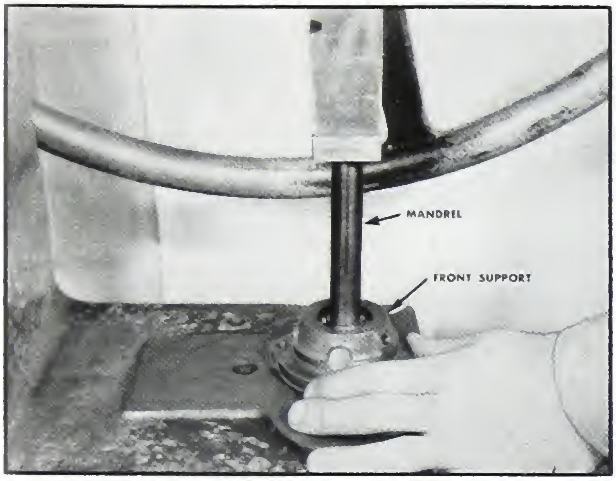


Fig. 5-311. Pressing bearing and retainer from support

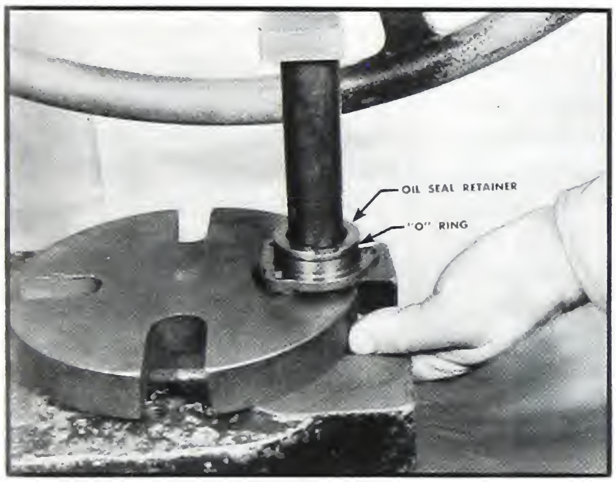


Fig. 5-312. Pressing out oil seal

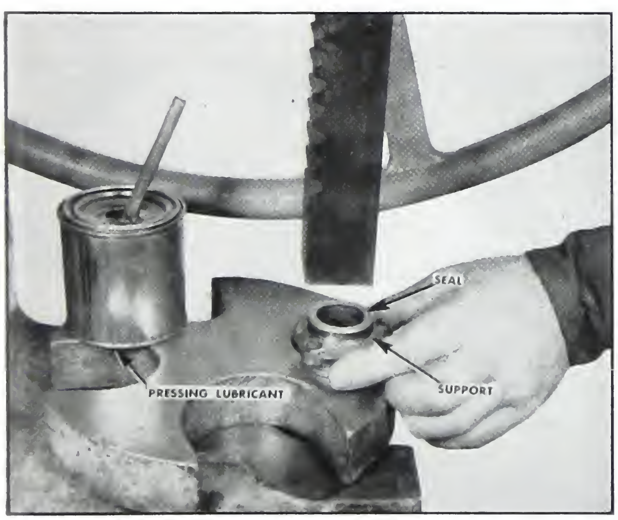


Fig. 5-313. Assembling oil seal to bearing retainer

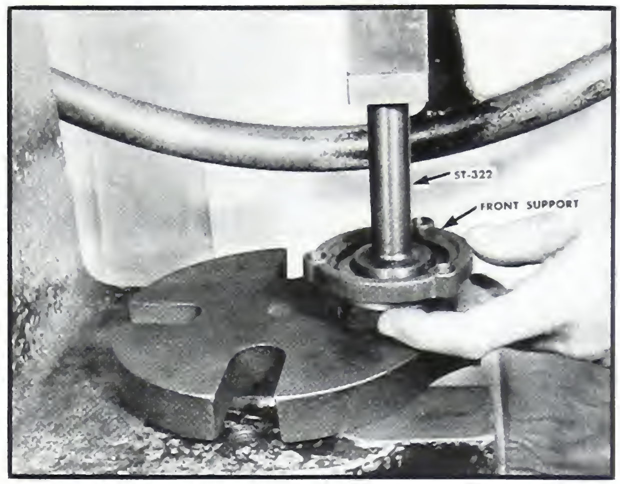


Fig. 5-314. Assembling bearing to support

Main Shaft Support

1. Remove the three socket head screws from the front bearing retainer.
2. Press the bearing, retainer, and oil seal out of the front support. Fig. 5-311.
3. Press the oil seal out of the bearing retainer. Fig. 5-312.
4. Inspect bearing for rough races and cracked balls.
5. Replace the retainer "O" ring and press in the oil seal. Fig. 5-313.
6. Press the ball bearing to the flange in the front support with ST-322 mandrel. Fig. 5-314.
7. Press the front bearing retainer in the bearing support and secure with the three capscrews. Align notch on retainer with hole in support. Fig. 5-315.

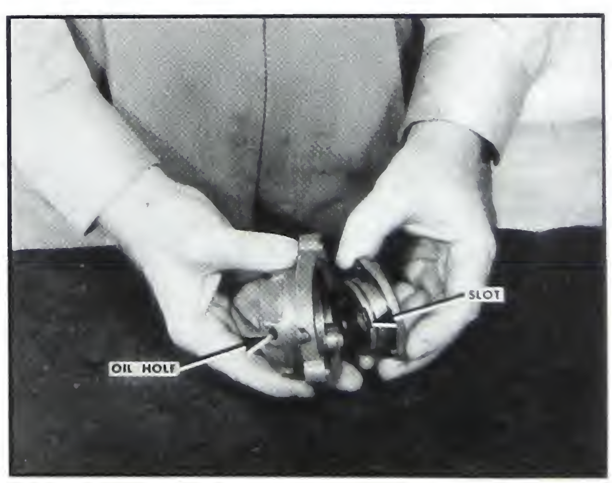


Fig. 5-315. Replace oil seal retainer

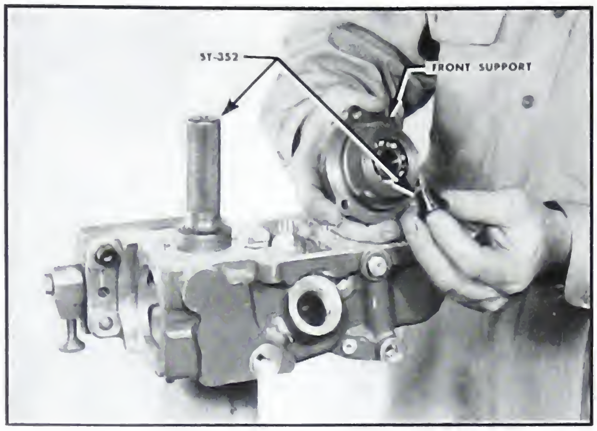


Fig. 5-316. Assemble ST-352 to main housing and support

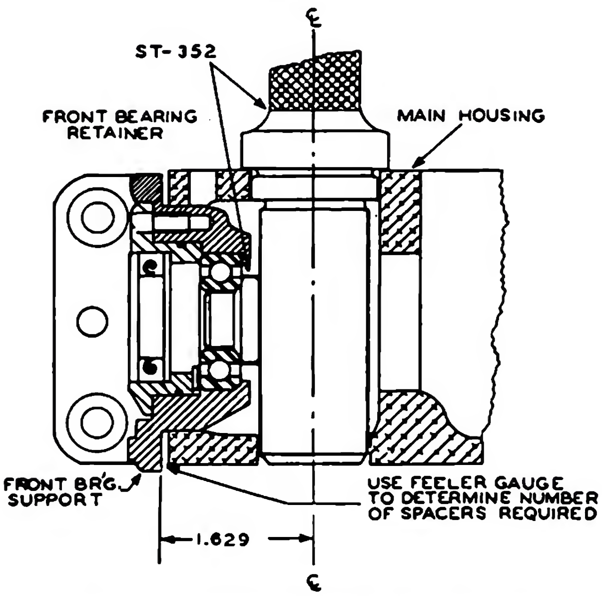


Fig. 5-317. Determining positon of camshaft

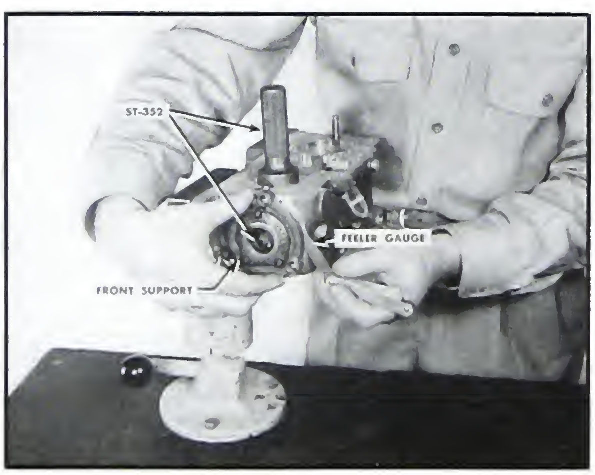


Fig. 5-318. Determine spacers required

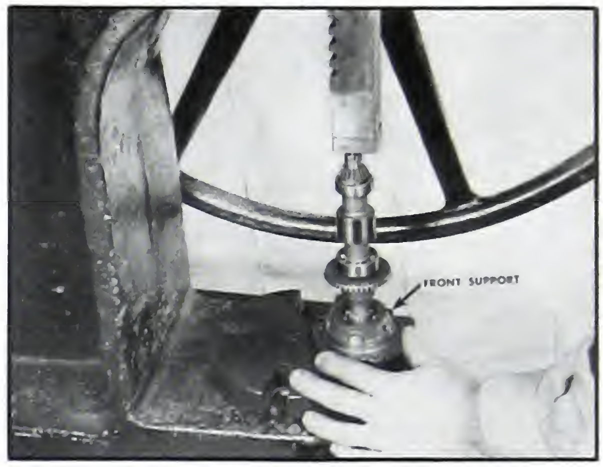


Fig. 5-319. Assembling front support to camshaft

8. Using the front bearing support and ST-352 assembly gauge, determine the amount of gaskets needed between the front bearing support and the main housing to set the camshaft in the proper position. ST-352 tools are used in place of actual parts to determine the correct position as shown in Fig. 5-315 and Fig. 5-317.

9. Use a feeler gauge between the support and housing; then, add sufficient gaskets to fill the space. Fig. 5-318.

10. Using ST-320 and ST-321 tools, press the front bearing support on the camshaft. Fig. 5-319.

11. Assemble the drive coupling key to the camshaft and press on the drive coupling. Secure with washer and locknut to 50 foot-pounds with a torque wrench. Fig. 5-320.

12. Assemble the disc drive gear to the camshaft with washer, and locknut. Tighten to 45 foot-pounds with a torque wrench. Fig. 5-308.

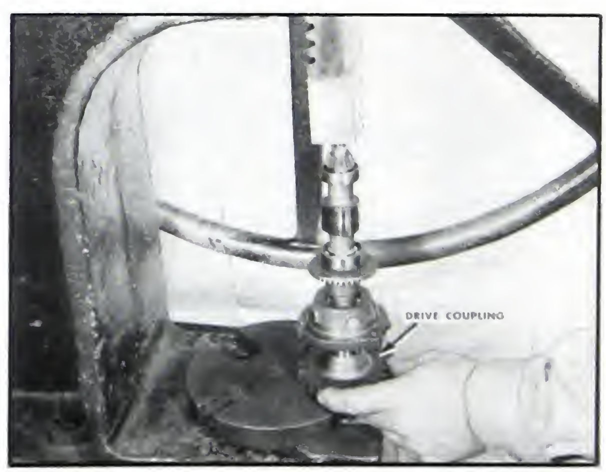


Fig. 5-320. Assembling drive coupling to camshaft

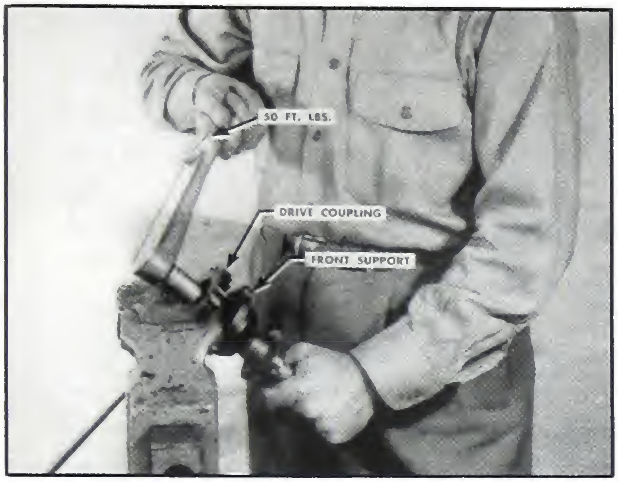


Fig. 5-321. Torque drive coupling nut

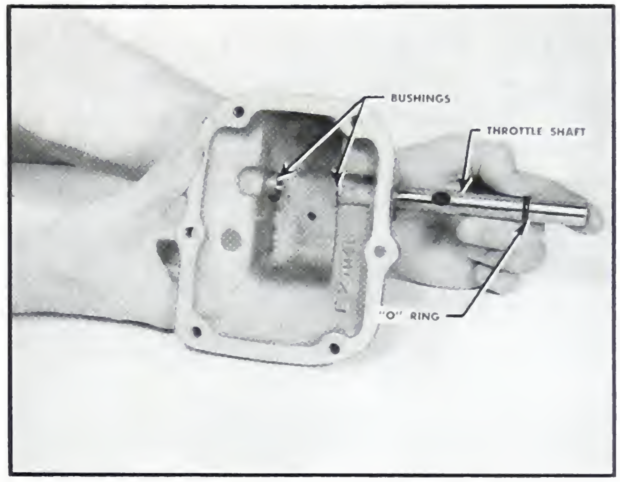


Fig. 5-322. Insert throttle shaft

NOTE: Disassembly of the disc drive gear requires that the camshaft be retimed to the distributor. See Page 5-102. "Timing Camshaft to Disc Driving Gear."

13. Pumps with rear couplings for hydraulic governors have spacers between the coupling and disc drive gear. Their assembly is covered when the main shaft is installed.

Governor Cover

The governor cover for the variable-speed mechanical governed pump contains the throttle linkage and speed adjusting screws; other DD pump covers are plain and require no repair unless the mating surface is damaged or the cover is cracked.

1. There are two bushings in the variable-speed governor cover; however, repair to the cover will be very rare since the throttle shaft moves very little and because the shaft is sealed by "O" rings which ride on the bushings. If replacement is required these bushings must be bored to .560/.561.

2. Replace the "O" rings on the throttle shaft and lubricate thoroughly before assembling the shaft to the cover.

3. The throttle yoke is connected to the throttle shaft by a lever; these parts are in turn connected by a pin. If pin, yoke or lever must be replaced, press out the pin and replace the damaged part. To assemble simply press the pin through until it protrudes an equal amount on each side of the assembly.

4. Insert the throttle shaft into the governor

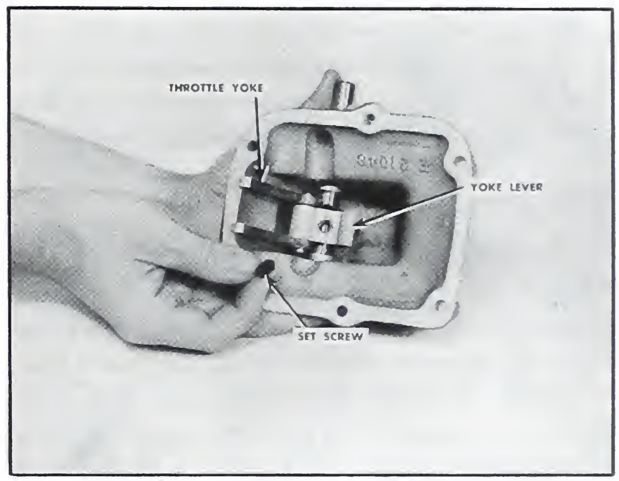


Fig. 5-323. Assemble throttle yoke assembly to cover

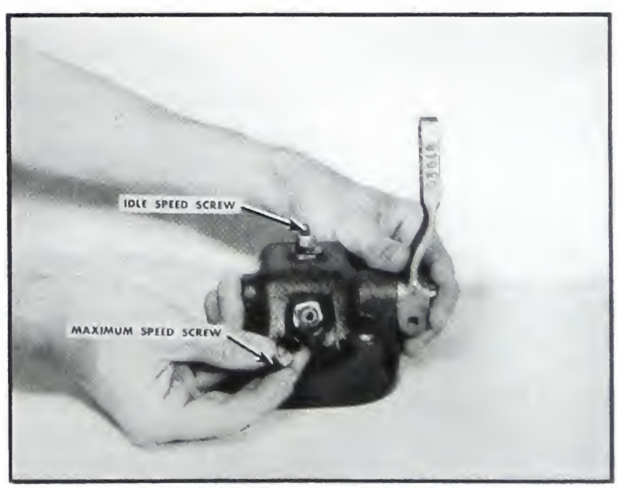


Fig. 5-324. Screw in adjusting screws

cover. Fig. 5-322.

5. Place the throttle yoke and lever in the cover and slide the throttle shaft through the lever. With the lever in position assemble the set screw into the lever so the point seals in the throttle shaft recess and tighten in place, then prick punch the set screw so it cannot come loose. Fig. 5-323.

6. Assemble the throttle lever to its shaft.

7. Screw the idle and maximum screws, copper washers and lock nuts into the cover. Fig. 5-324.

ASSEMBLY AND ADJUSTMENTS

In the assembly of the DD pump be sure all burrs are removed from all mating parts. Use a high pressure lubricant on all assemblies that are pressed within the housing or other parts. This will aid in pressing and help prevent scoring or galling of parts.

Flat steel washers are required next to all aluminum parts when a steel lockwasher is used.

The following assembly and adjustment instructions are given with the assumption that worn or defective parts, or sub-assemblies, have been replaced with new or properly rebuilt parts and assemblies.

Main Or Camshaft

Normally if no parts have been replaced, the camshaft can be pressed back in the main housing using the same number of front support spacer gaskets as it had when disassembled. If parts have been changed, the position of the camshaft in the housing must be adjusted to give proper back lash to the mating gears. See Fig. 5-318.

If the disc driving gear has not been disturbed or if the disc driving shaft has not been changed, lining up the marks made during disassembly will eliminate lengthy timing procedure.

Fig. 5-325. Heat main housing

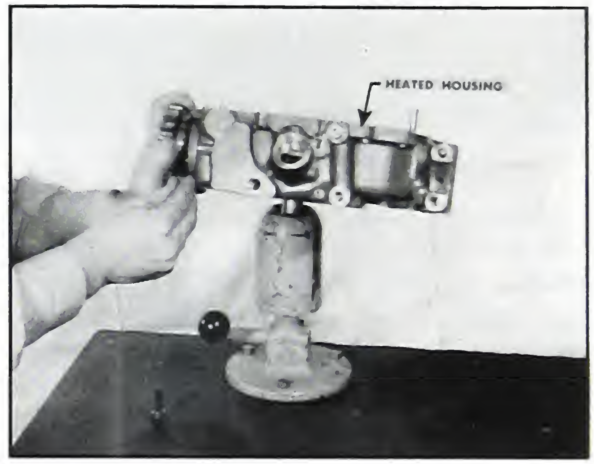


Fig. 5-326. Assemble camshaft to heated main housing

1. Heat the main housing to 190/200° F. in an oven.

NOTE: An oven can easily be made by using a heat bulb inside a metal box such as shown in Fig. 5-325.

2. With the front bearing lubricating drain hole toward the bottom of the main housing and using the proper number of front bearing support gaskets, push the camshaft in place in the main housing. Fig. 5-326.

3. Secure the camshaft with three 1/4"—20 x 7/8" socket head capscrews and three lockwashers.

Disc Drive Shaft Assembly

The disc drive shaft assembly is a light press fit in the main housing, and the disc driven gear meshes with the disc drive gear on the camshaft.

If the disc drive shaft has not been changed or if the disc driving gear on the camshaft has not been disturbed, the timing marks made during disassembly can be lined up to eliminate the lengthy timing procedure.

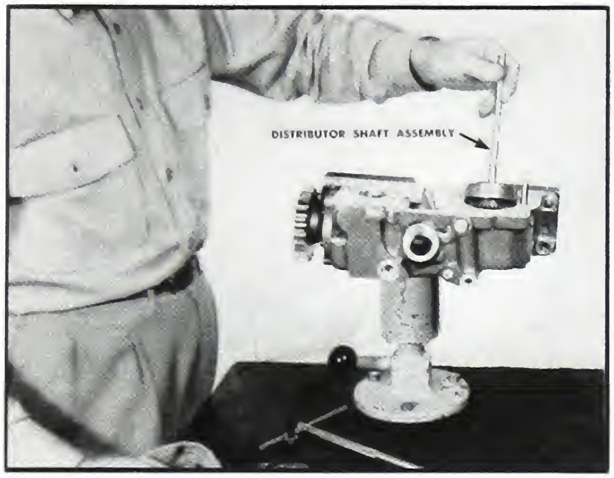


Fig. 5-327. Assemble distributor shaft assembly to main housing

1. Drive disc drive shaft assembly in place with ST-324 driving mandrel and a light plastic hammer. Move camshaft, as needed, while driving to insure proper meshing of gears. Fig. 5-327.

By putting this assembly in while the housing is still hot from the previous operation, much time can be saved.

2. Use spacers between ball bearing and suction plate to give .002 to .004 backlash between disc driving gears.

3. Check depth of disc drive bearing in housing (Fig. 5-328), then check height of boss on the suction plate. (Fig. 5-329).

4. Add sufficient spacers to fill the difference between the bearing and suction plate and add a .002 gasket; this will provide proper backlash.

Suction Plate And Disc

The suction plate assembles to the lower housing with six ¼"—20 x ¾" socket head capscrews and lockwashers. Its location is determined by the same locating dowel that locates the upper housing to the main housing. Fig. 5-330.

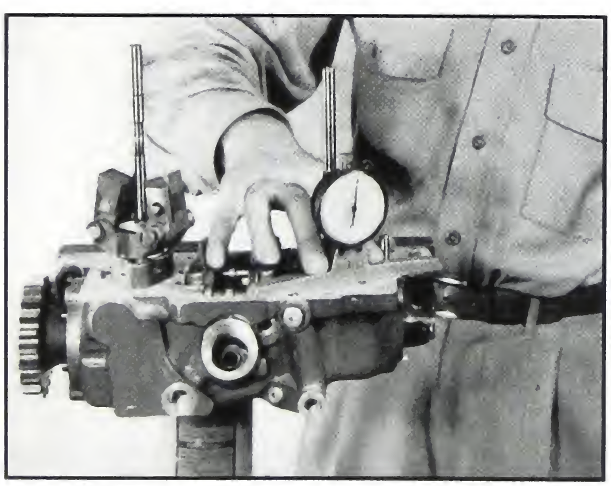


Fig. 5-328. Check depth of bearing

Fig. 5-329. Check height of suction plate boss

1. With a new plate gasket, assemble the suction plate to the lower housing. Tighten the six capscrews securely.

2. Apply a generous supply of vaseline to the disc and assemble the disc to the plate. Fig. 5-330.

NOTE: Distributor shaft splines are offset for proper indexing.

Cam Rocker Lever Assembly

1. Assemble cam rocker lever brackets to the cam rocker lever with the stop assembled to the distributor side of the rocker lever and the long arm of the rocker lever assembled towards the

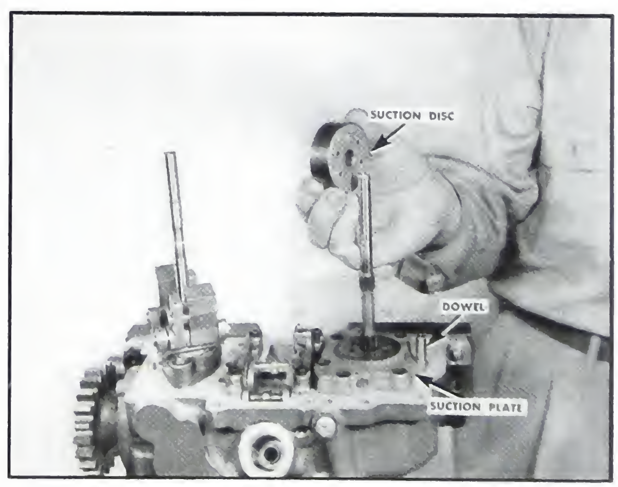


Fig. 5-330. Assemble suction disc

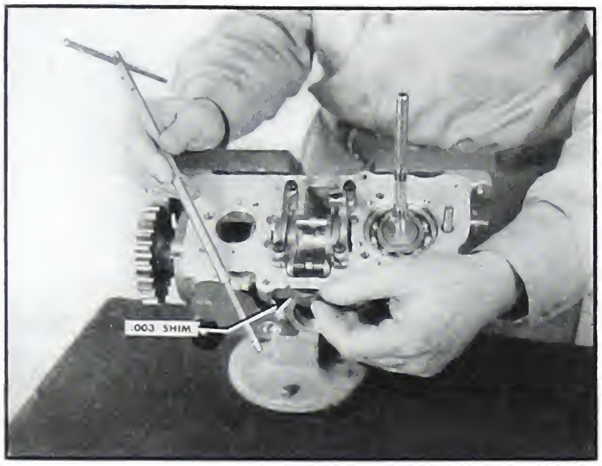


Fig. 5-331. Assemble cam rocker assembly

opening for cam rocker lever spring retainer. Fig. 5-331.

2. Check for free movement. Leave approximately .003" clearance between each bracket bushing and the rocker lever. Fig. 5-331.

3. Tighten the four ¼"—20 x 1" socket head capscrews and recheck for free action. Rocker lever should rock freely when tightened in position.

4. Use a new gasket and assemble the shut-down spring retainer, spring and cap to the lower housing. Fig. 5-332.

5. Check to see that the retainer is riding against the idle shut-down lever.

6. Assemble the cam rocker lever spring and retaining nut with a new gasket.

7. Insert the assembled retainer so that spring fits flat against the cam rocker lever, and tighten securely.

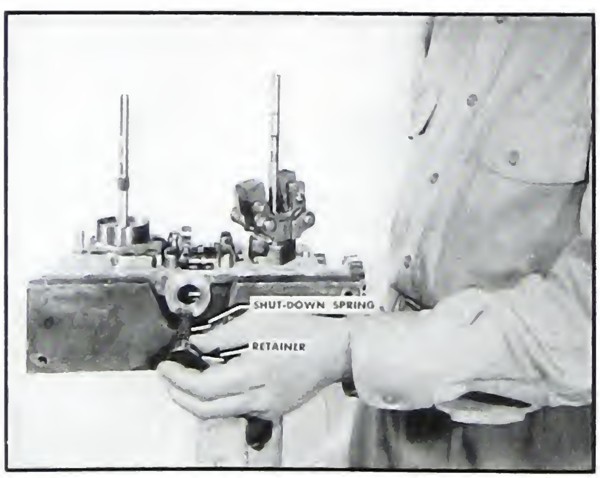


Fig. 5-332. Insert shut-down spring and retainer

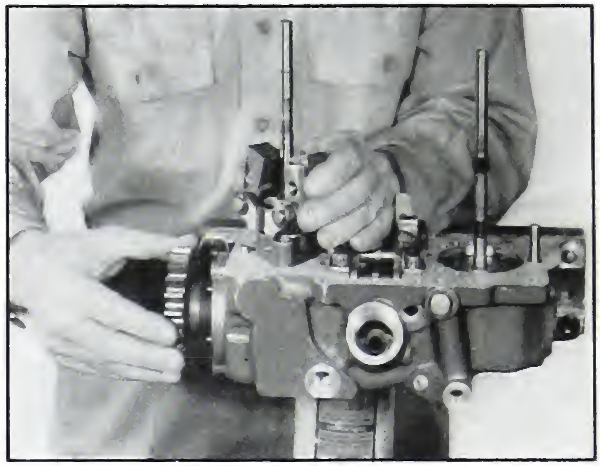


Fig. 5-333. Check governor drive backlash

Mechanical-Governor Drive Shaft Support And Weight-Carrier Assembly

The governor drive shaft and weight carrier assembly can be assembled to the main housing either before or after the upper housing is in place. The drive shaft and weight-carrier is held to the main housing by the governor bearing support, and it is secured by two ¼"—20 x 1" socket head capscrews and lockwashers.

1. Use an air hose to check lubricating passage.

2. Assemble a .032" laminated spacer to the drive shaft assembly and insert in the main housing. The spacer is used to establish back lash as described in Step 4 following. Fig. 5-333.

3. Check to see that oil hole indexes with oil hole in lower housing. Secure the governor bearing support with two capscrews and lockwashers. Fig. 5-333.

4. Check back lash in governor drive gear. Back lash should be .002 to .004. Remove spacer stock as necessary. A new spacer is approximately .032 thick and has 16 layers of .002 spacer stock. Fig. 5-210. Check by locking main shaft and holding governor weights in, then shake.

CAUTION: WITHOUT PROPER BACK LASH, THE GEARS WILL WEAR EXCESSIVELY AND FAIL.

Upper Housing

The upper housing is located to the main housing by two locating dowels one on each end of the pump—and it is secured by nine ¼"—20 x 1"

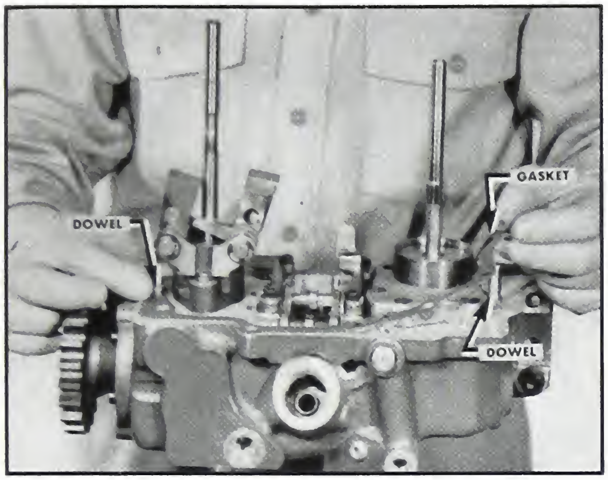


Fig. 5-334. Replace upper housing gasket

socket head capscrews, lockwashers and flat washers.

1. Before assembly, check to see that linkage and metering plunger are in proper working order.

2. Set a new gasket in place on the main housing. Fig. 5-334.

3. With one hand through the top of the governor housing to hold the vertical lever in the metering plunger, set the upper housing in place on the main pump housing. Fig. 5-335.

4. Secure the housing with nine capscrews, lockwashers and flat steel washers. Use the flat washer next to aluminum.

NOTE: Three of the housing hold-down screws are assembled inside the governor housing. Fig. 5-336.

5. Check the linkage to see that the vertical lever works freely on the cam rocker lever. Fig. 5-336.

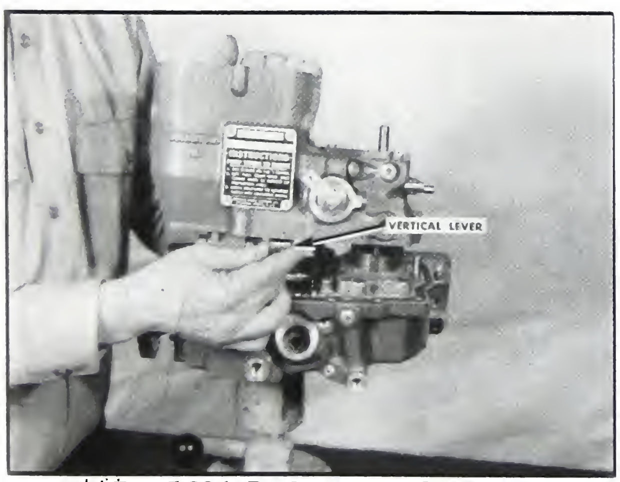


Fig. 5-335. Replace upper housing

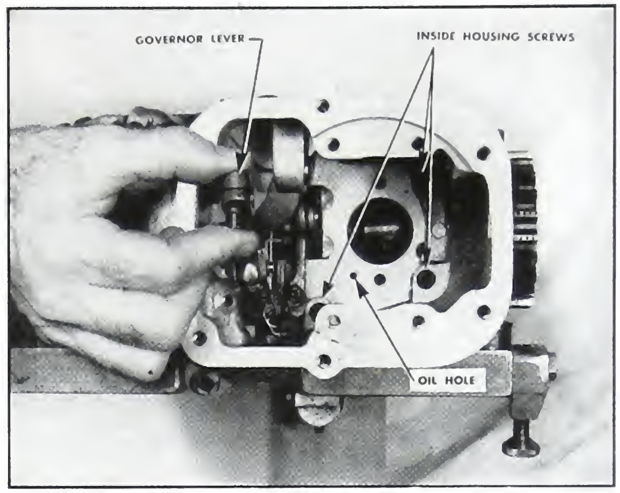


Fig. 5-336. Checking freeness of vertical lever

Discharge Cover And Disc

The discharge disc and suction disc are assembled to the disc drive shaft on offset splines and are held in working position by the compression of the disc spring. The discharge cover assembles to the upper housing against disc spring compression by six ¼"—20 x 1" capscrews and lockwashers.

The disc for right-hand pumps has the timing mark 47° from filling hole. Left hand pump discs have the timing mark 173° from the filling hole.

1. Check to see that the suction disc has been assembled. Insert disc and spring discharge disc. Spring dimensions are 2.137 in. free length and 1 13/32 in. at 300 lbs. ±10 lbs. Fig. 5-337.

2. Apply a coat of clean vaseline or Lubriplate to the cover and disc. Fig. 5-338.

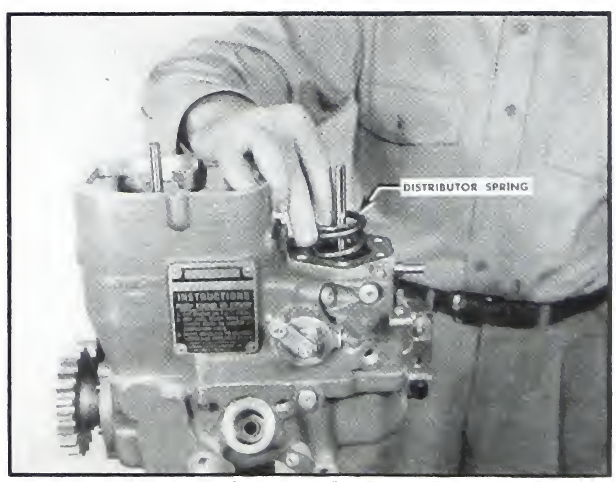


Fig. 5-337. Replace distributor spring

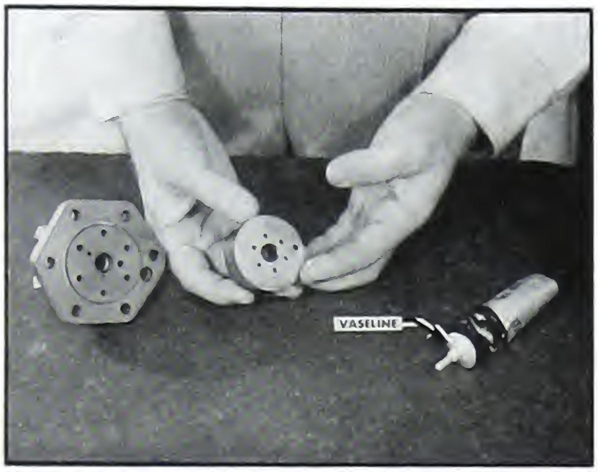


Fig. 5-338. Coat disc with vaseline

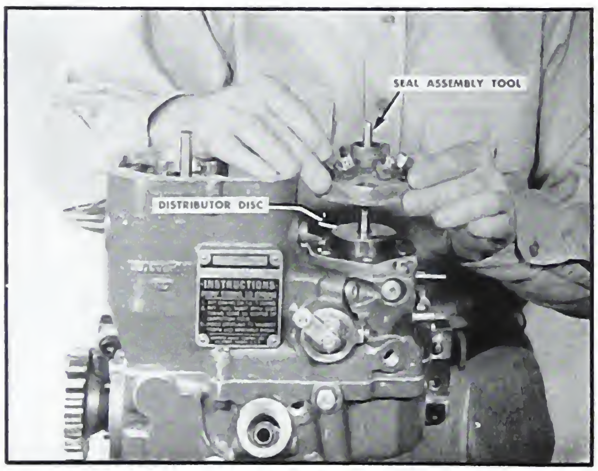


Fig. 5-339. Assemble distributor cover

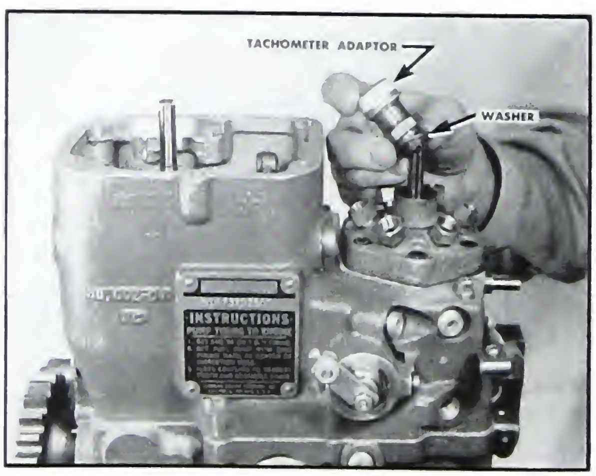


Fig. 5-340. Replace tachometer adapter

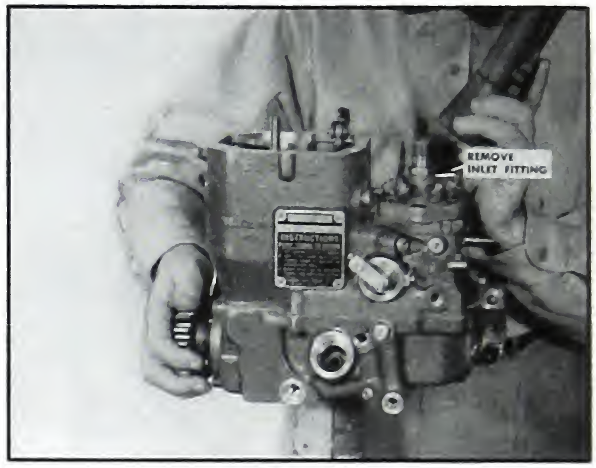


Fig. 5-341. Align filling hole

3. Use a new gasket and place cover in position over the disc drive shaft, being careful not to damage the cover oil seal. The cover is located over a hollow dowel in the housing. Fig. 5-339.

4. Assemble the six socket head capscrews and lockwashers. Tighten two opposing capscrews a little at a time, to compress the disc spring.

NOTE: Two 1/4"—20 x 1 1/2" capscrews can be used to compress the spring far enough to start the shorter 1" screws.

5. Replace the tachometer drive adapter, copper washer and cover. Fig. 5-340.

Timing Camshaft To Disc Driving Gear

1. Remove the cam rocker lever spring and retainer, and insert timing tool ST-356.

2. Align the filling hole in discharge disc with the hole in the discharge cover (this is the connection that is drilled at an angle different from the others), by sighting through the hole while turning the camshaft. Fig. 5-341.

3. Loosen the pump rear coupling nut and loosen the drive coupling. Make sure the disc has not moved. Fig. 5-342.

4. Rotate the camshaft and find the low point of indicator travel. Set the indicator to "O". Make sure distributor drive gear is loose on the taper. Fig. 5-343.

5. Rotate the camshaft in direction of engine rotation and find the high point of indicator travel. Fig. 5-344.

6. Rotate the camshaft in engine rotation until

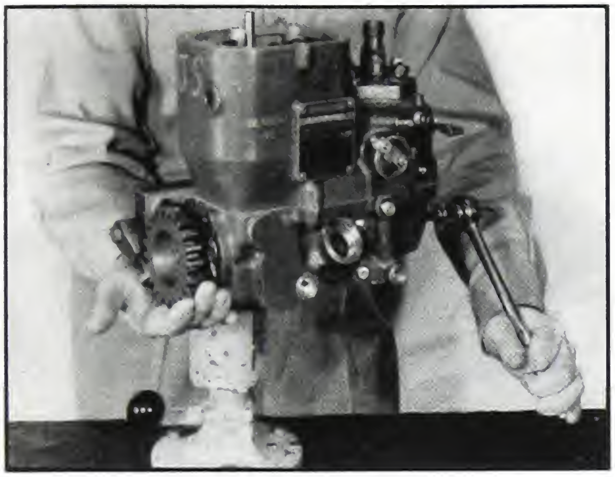


Fig. 5-342. Loosen coupling nut

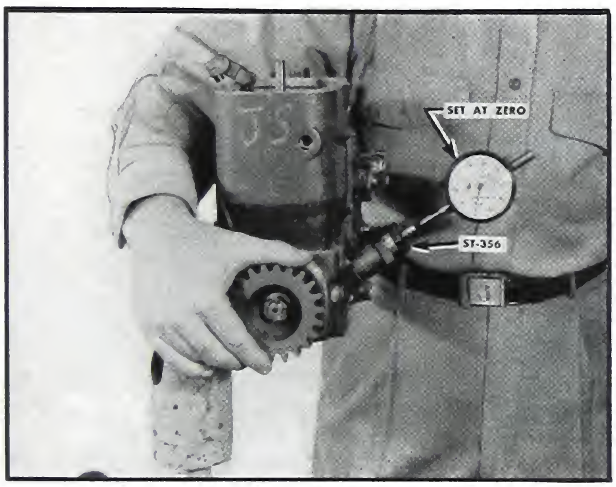


Fig. 5-343. Low point of travel

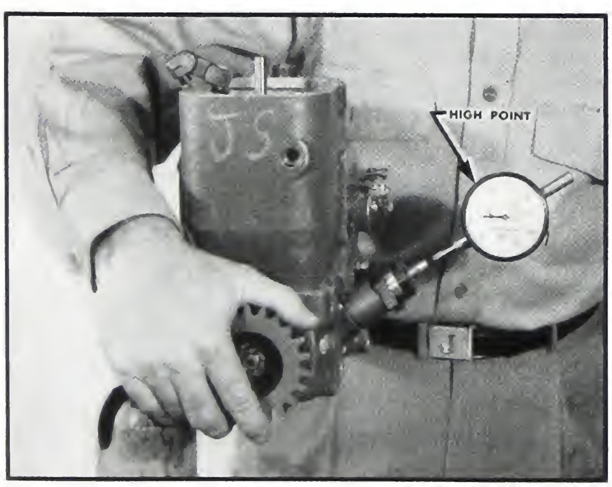


Fig. 5-344. High point of travel

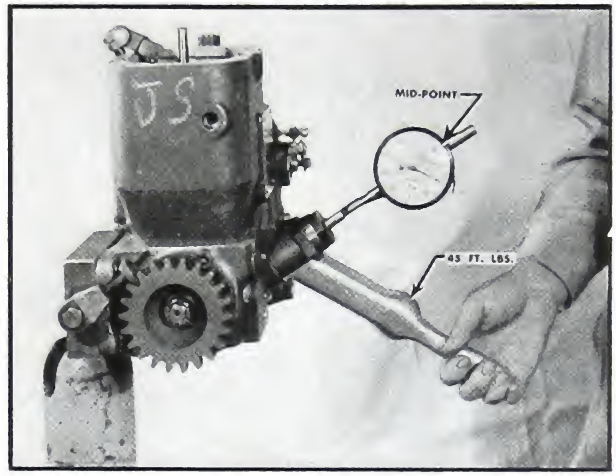


Fig. 5-345. Torque drive nut

the dial indicator shows the cam rocker lever to be in mid-position plus .025 toward the high point of travel.

7. With the dial indicator resting at this position and with the disc still aligned as described in "Step 2", hold the coupling and tighten the disc driving gear nut to 45 foot-pounds with a torque wrench. Fig. 5-345.

8. Recheck the timing after tightening the pinion gear nut.

9. Remove the timing tool and insert the cam rocker spring retainer assembly.

Governor Control Units

The thrust bearing, sleeve, and sleeve guide convert the centrifugal weight action of the rotating weight carrier to vertical action against the maximum speed spring and governor yoke.

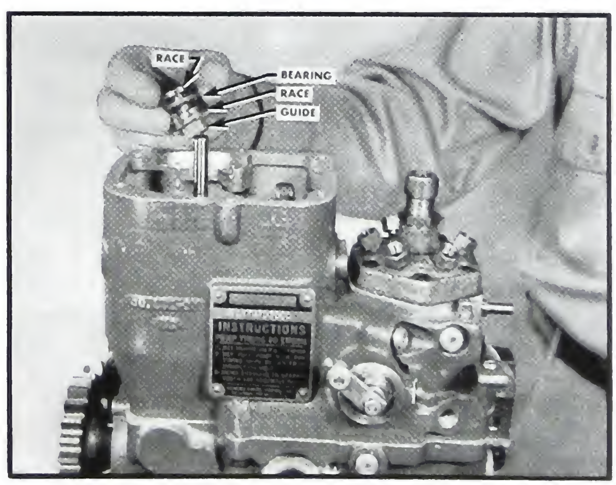


Fig. 5-346. Assemble thrust bearing and sleeve guide

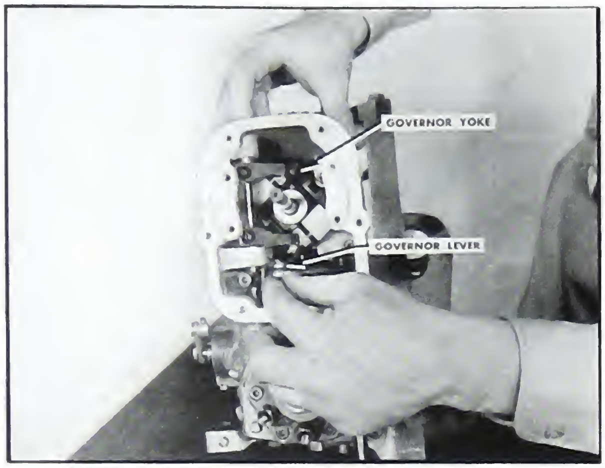


Fig. 5-347. Insert governor shaft

The governor yoke is clamped to the control shaft and transmits the governor action through the control shaft and governor lever to the linkage. The assembly is completed by tightening the ¼" socket head clamping screws. Fig. 5-347.

1. Assemble the thrust bearing to the sleeve guide. The bottom race is a finger press fit while the top race fits loosely. The open face of the cage fits down against the bottom race. Fig. 5-346.
2. Insert the sleeve guide so that milled-out sections fit between the pawls on the maximum speed weights.
3. Insert the governor shaft through the governor yoke and governor lever. Clearance should be checked as shown in Fig. 5-347.
4. Assemble the governor sleeve over the drive shaft and into the yoke. Fig. 5-348.
5. Insert the governor maximum speed spring. Fig. 5-349.

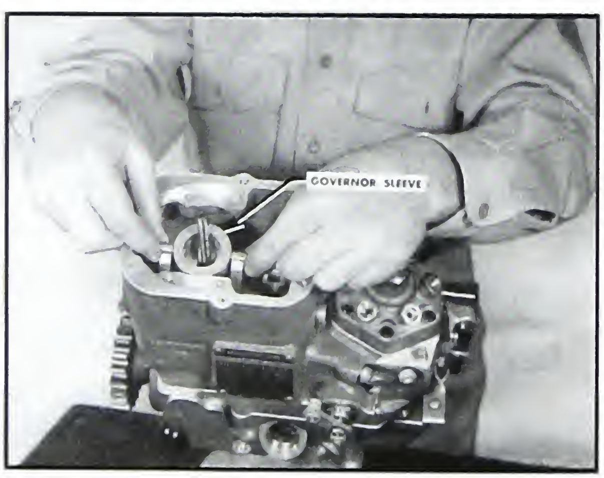


Fig. 5-348. Replace governor sleeve

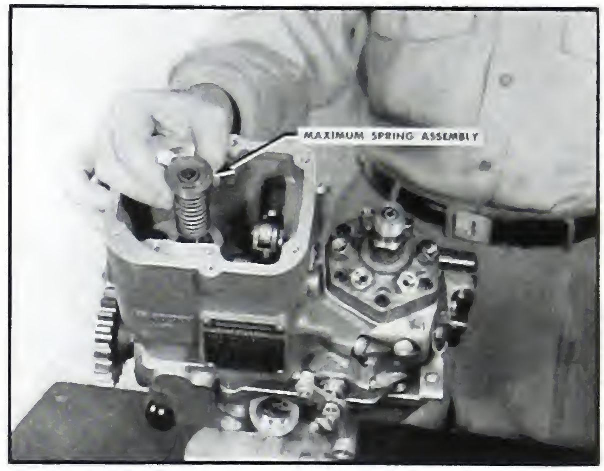


Fig. 5-349. Replace maximum speed spring

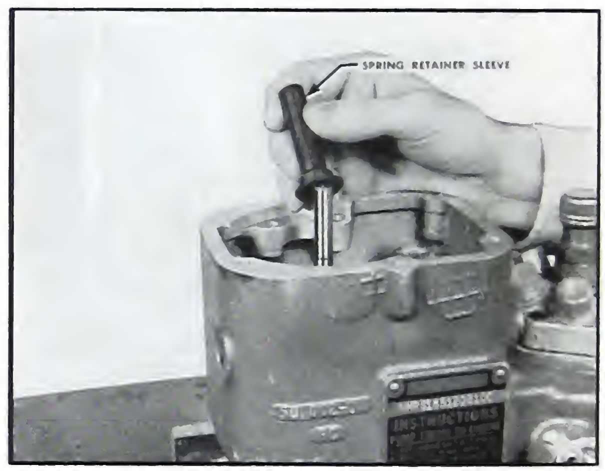


Fig. 5-350. Install spring retainer sleeve

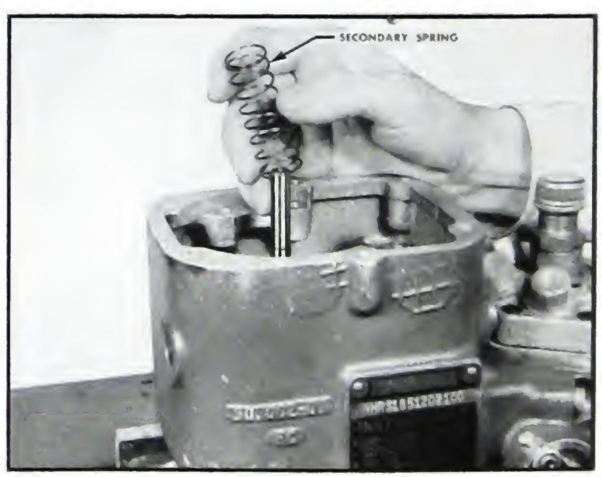


Fig. 5-351. Install secondary spring

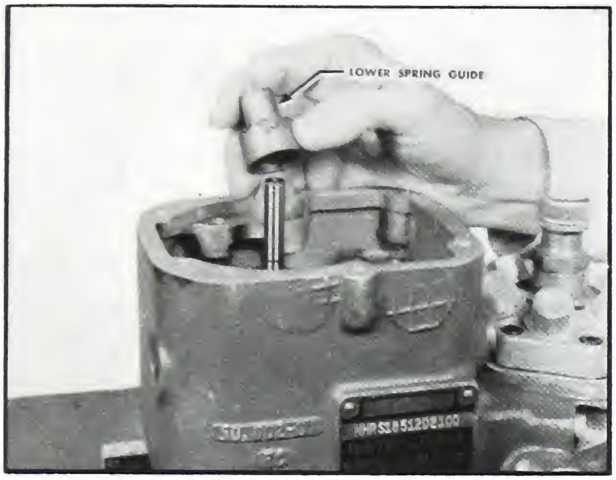


Fig. 5-352. Slide on the lower spring guide

Steps 6 Through 13 Are For Variable-Speed Governor Only:

6. Install the spring retainer sleeve. Fig. 5-350.

7. Put the secondary governor spring over the spring retainer sleeve. Fig. 5-131.

8. Slide the lower spring guide down over the governor shaft and secondary governor spring. Fig. 5-352.

9. Follow the lower spring guide with the governor spring and upper spring guide. Fig. 5-353. The guide must be positioned so the throttle yoke will fit between the prongs on the guide.

10. Install the governor top support and secure in place with four sockethead screws and washers.

11. Connecting Governor Linkage-Variable-Speed Governor:

A. Use a small punch to hold the governor control shaft down so the sleeve is seated on the thrust bearing. Fig. 5-348.

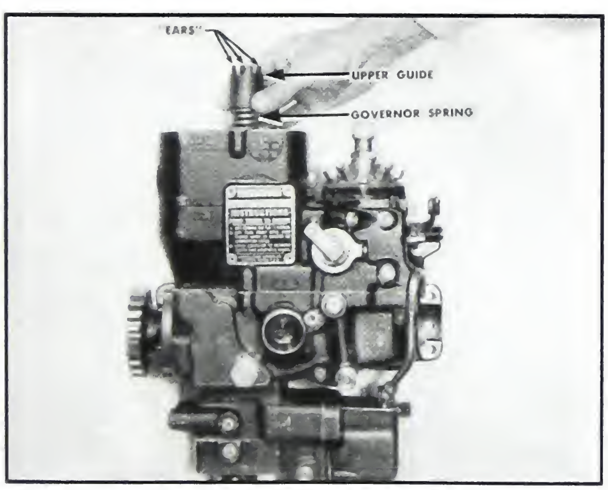


Fig. 5-353. Install spring and guide

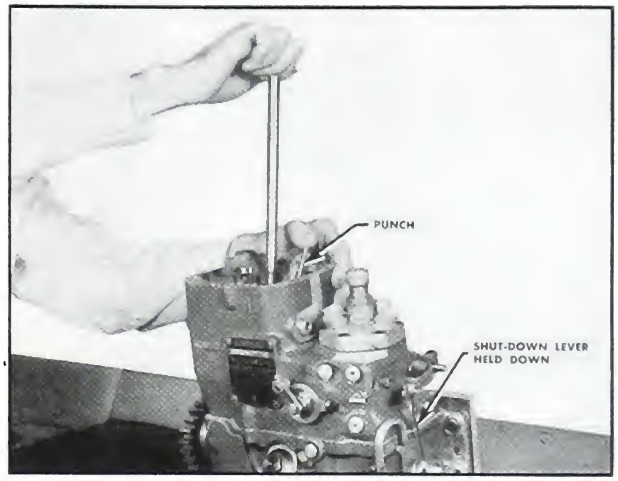


Fig. 5-354. Connect the governor lever

B. Secure the shut-down lever down. Fig. 5-354.

NOTE: The hand control lever on a variable speed mechanical-governor fuel pump is used only to shut down the engine. The throttle control is located on top of the governor cover.

C. Hold the governor lever against its maximum stop by backward pressure on the wrench and tighten in place. Fig. 5-354.

NOTE: All three of the above operations must be done simultaneously to properly set the governor lever.

12. Install the governor cover assembly making sure that the throttle yoke indexes between the prongs of the upper spring guide.

13. Governor speed adjustments are to be made on the fuel pump test stand by changing the adjusting screw setting on the governor cover. See Fig. 5-324.

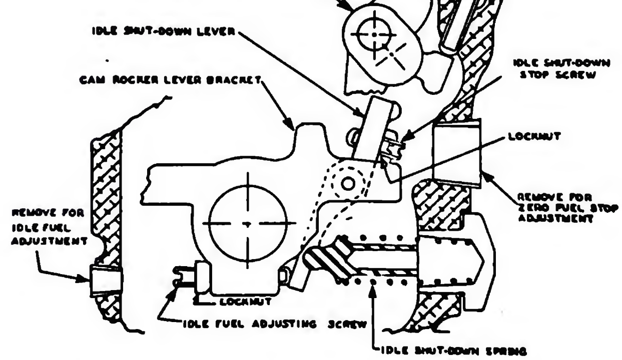


Fig. 5-355. Adjustment of idle shut-down lever

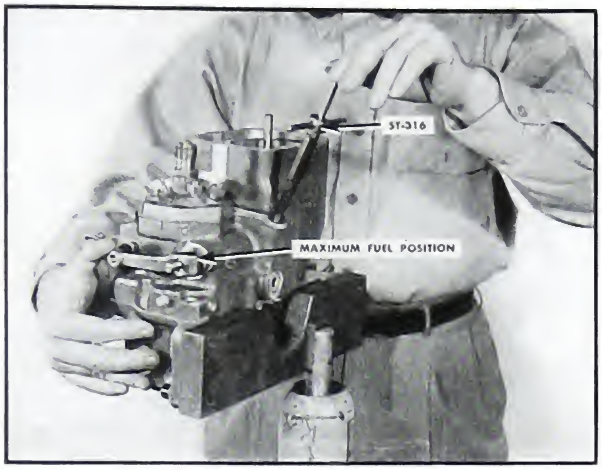


Fig. 5-356. Set maximum fuel

Adjustments, Governor And Hand Control, Maximum Speed Governor

MAXIMUM FUEL AND HAND CONTROL LEVER: The eccentric adjustment locates the eccentric and hand control to obtain proper angularity of linkage and insure responsive throttle movement.

1. Assemble hand control lever to outer end of eccentric shaft.

2. While holding throttle control down as far as it will go in maximum-fuel position, screw in the maximum fuel adjustment screw until it just starts to move the hand throttle lever. Turn one-half turn more, and lock. Fig. 5-356. This maximum fuel setting is approximately 2% over required delivery. Further adjustment is made on the fuel pump test stand.

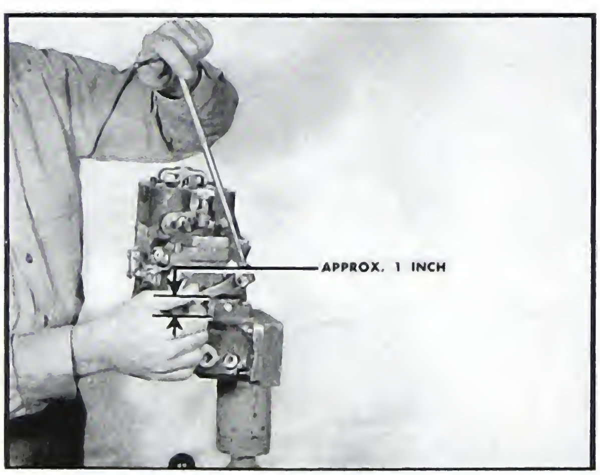


Fig. 5-357. Tighten hand control lever in position

3. Set the hand control lever at the position required for maximum fuel. Usually this lever will form a 30° angle in relation to the parting line between the center and lower pump housings. The center of the throttle lever hole would be approximately 1 inch above the parting line of the housings. Fig. 5-357.

MECHANICAL-GOVERNOR IDLE TRAVEL ADJUSTMENT: The purpose of the idle travel adjustment is to synchronize the action of the idling weights with the counter-action of the idling spring. The idling weights must contact their stops at the same time the idle spring travel is completed.

1. Assemble the top support to the housing without the idle spring. Use four ¼"—20 x 1" socket head capscrews, lockwashers and flat steel washers. Keep the flat washers next to the aluminum. Fig. 5-358.

2. Adjust the idle travel with the top support locking screw loose. Be sure governor lever is loose on the control shaft. The large weights are for idle speed control and the small weights are for maximum speed control. For this adjustment, choose the idle speed weight which hits its stop last. While the idle-speed weight is held out against its stop, turn the idle-travel adjusting screw until it just contacts the maximum-speed spring retainer sleeve. Fig. 5-359. Contact can be felt by feeling the screw hit while turning. Lock the idle travel locking screw. Fig. 5-360. Use extreme care in this adjustment. If idle travel is not completed at the same time the low speed weights hit their stop, there will be a noticeable

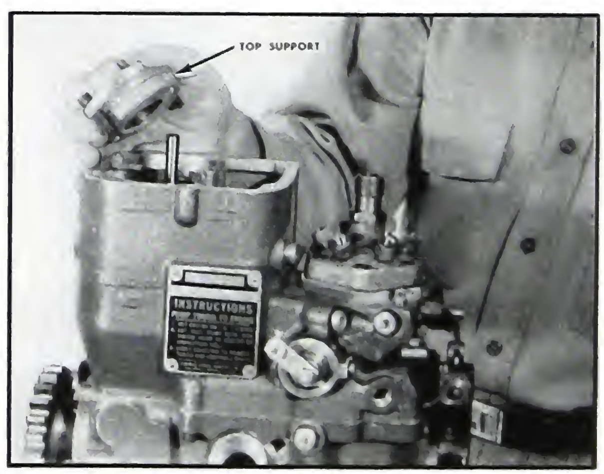


Fig. 5-358. Assemble top support

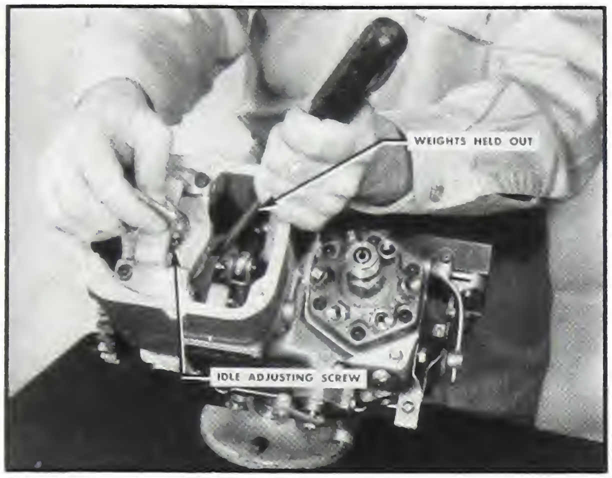


Fig. 5-359. Turn down governor idle adjusting screw

drop in engine torque.

3. As an additional check, hold the idle speed weights out and turn the maximum speed spring assembly with one finger; there should be a slight drag but the spring must not be locked. Fig. 5-361.

CONNECTING HYDRAULIC GOVERNOR LINKAGE: 1. Hold the vertical lever linkage and throttle control down or in full-fuel position. Fig. 5-362.

2. Tighten vertical lever linkage to the governor control shaft.

3. Additional adjustments may be required on

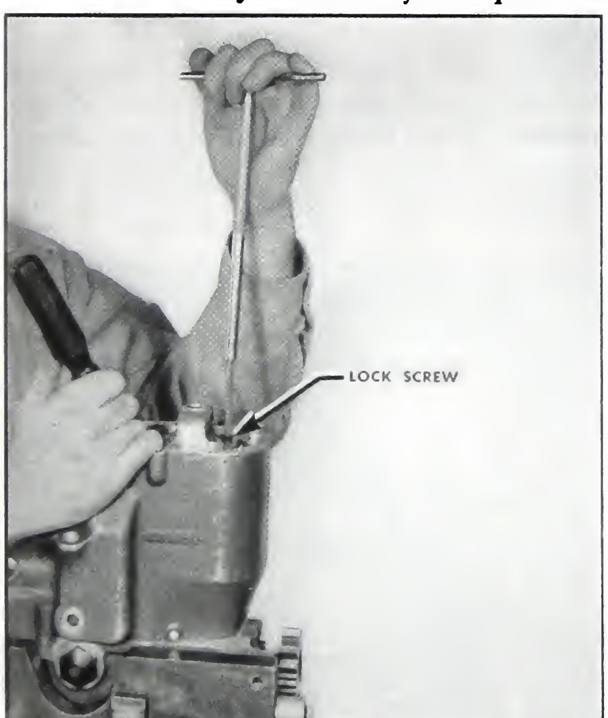


Fig. 5-360. Lock idle travel screw

Fig. 5-361. Check maximum-speed spring for drag

the fuel pump test stand.

CONNECTING MECHANICAL GOVERNOR LINKAGE: Connecting the governor linkage is one of the most important adjustments on the pump. It synchronizes the governor throttle control with the hand throttle control.

1. Hold or set throttle arm in maximum-fuel position. Fig. 5-362.

2. Take up idle travel by holding the heavy idling weights back against their stop. Fig. 5-362.

3. Hold the vertical arm against its maximum stop on the cam rocker lever by using downward pressure on the wrench.

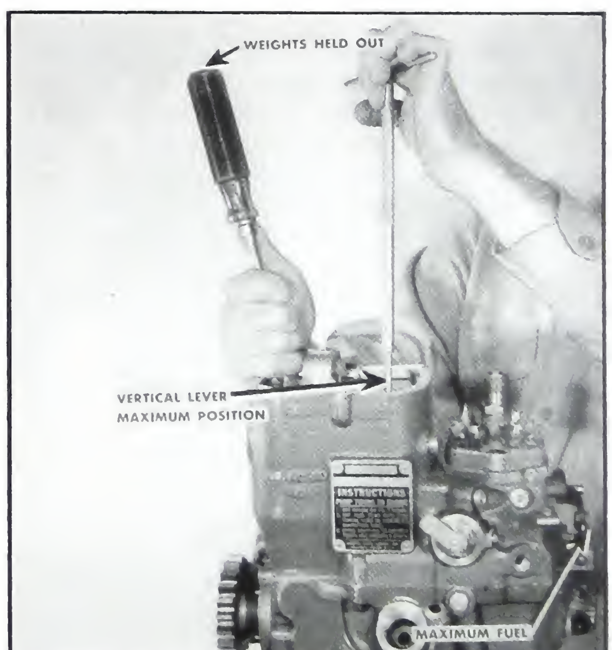


Fig. 5-362. Tighten governor lever in position

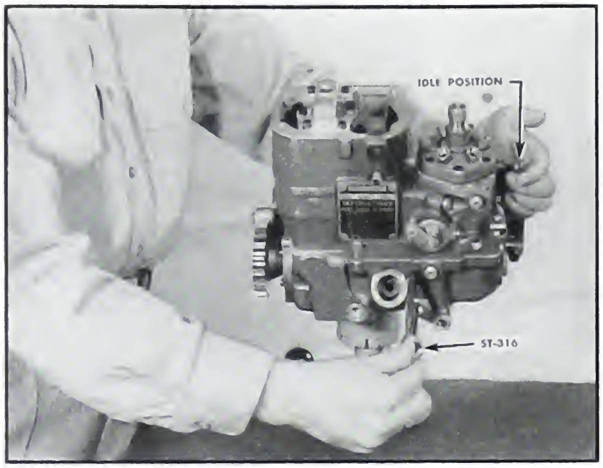


Fig. 5-363. Idle fuel adjustment

4. Lock the clamping screw.

NOTE: All four of the above operations must be done simultaneously to properly set the governor lever.

IDLE SHUTDOWN LEVER ADJUSTMENT: The idle shutdown lever adjustment determines the maximum idle-fuel and no-fuel positions of hand throttle.

IDLE FUEL ADJUSTING SCREW: 1. Take up idle-travel. (See Item 2, Conecting Mechanical Governor Linkage.) This can also be done by clamping the governor lever in idle position as shown in Fig. 5-363.

2. Hold hand control in idling position. This is as far as hand control lever will go without compressing shut-down spring.

3. Assemble adjusting screw and locknut to the cam rocker lever bracket through idle fuel adjusting hole with ST-316. Fig. 5-363.

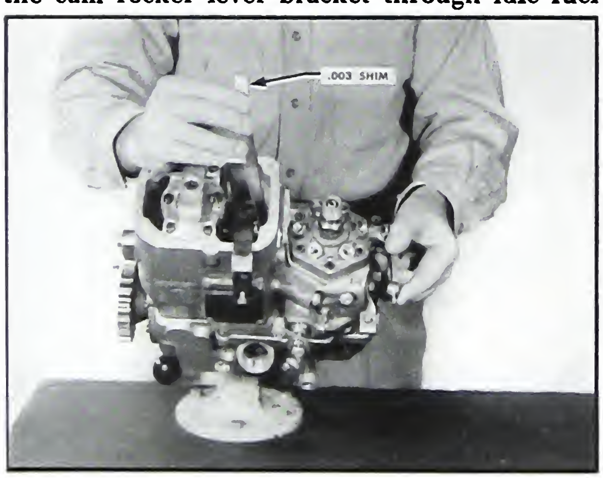


Fig. 5-364. Insert shim stock between vertical lever and zero stop

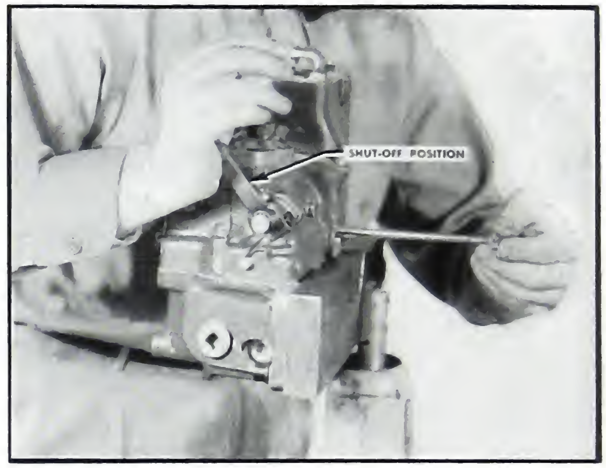


Fig. 5-365. Assemble zero stop screw

4. With a long piece of .003" shim stock between vertical lever roller and zero-stop sleeve, turn adjusting screw out until throttle lever starts moving downward. Turn adjusting screw in until throttle lever just stops moving upward. Turn one-half turn more and lock. Fig. 5-364.

ZERO STOP SCREW: 1. With idling weights free and idle travel extended—turn hand control lever back against and compress idle shut-down spring until vertical lever hits zero stop pin on rocker lever. Use a long piece of .003" shim stock to feel vertical lever hit stop pin.

2. Assemble zero stop screw and locknut to shutdown lever through fuel stop hole. Fig. 5-365.

3. Use ST-316 and screw in stop until it just begins to move hand control lever. Back out one-half turn and lock.

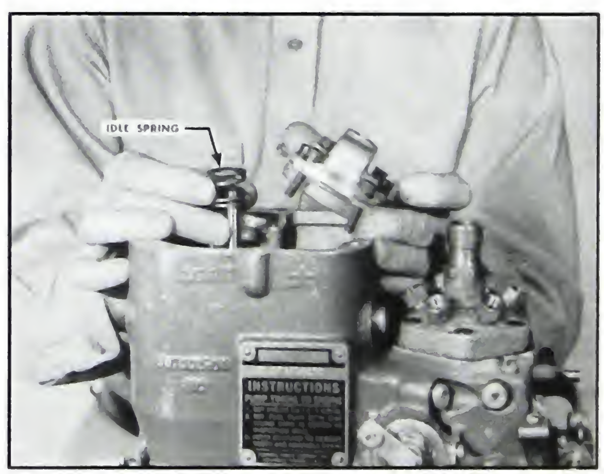


Fig. 5-366. Replace idling spring

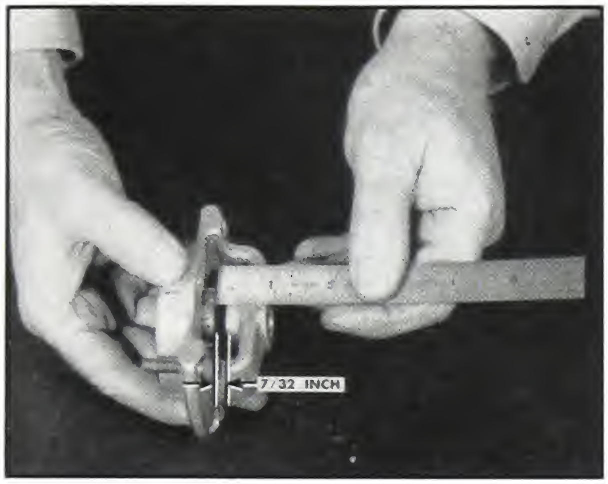


Fig. 5-367. Set idle adjusting screw

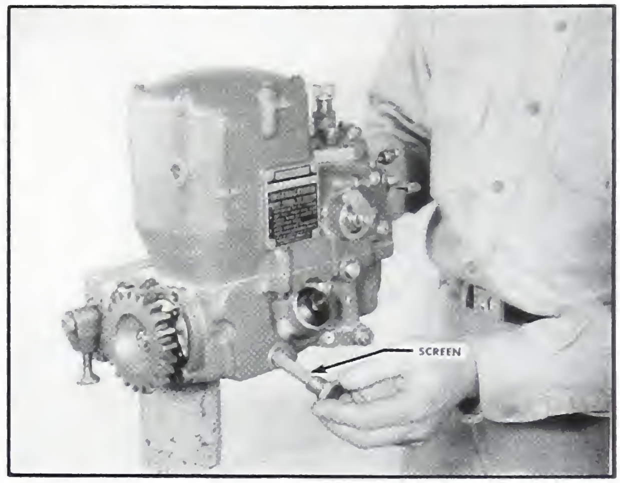


Fig. 5-369. Replace screen

MECHANICAL GOVERNOR IDLE SPEED ADJUSTMENT: The governor idle speed adjustment gives an approximate maximum idling adjustment of 600 rpm. Further adjustment can then be made on the engine by backing the adjusting screw out until the desired rpm is reached. Maximum idle speed possible by this adjustment is approximately 625 rpm.

1. Remove the governor top support and insert the idling spring. Fig. 5-366.

2. Turn the idle adjusting screw down until it is 7/32 inch from the top bearing support. Fig. 5-367.

3. Assemble the top support to the upper housing and secure in place. Assemble with the idle lock plate toward the distributor side of the pump.

4. Further idle travel can be set on the engine by using the lockplate as a wrench.

MECHANICAL HIGH-SPEED GOVERNOR ADJUSTMENT: High-speed governor adjustment should be made after the pump is assembled on the test stand. Maximum engine speed is adjusted by adding or removing shims under the high speed governor spring. Adding shims raises the maximum speed; removing shims lowers the maximum speed.

THROTTLE RETURN SPRING: 1. Assemble the spring sleeve and spring over the eccentric shaft. Fig. 5-368.

2. Hook the short end of the spring under the throttle hand control lever and the long end around the post in the upper housing. Fig. 5-368.

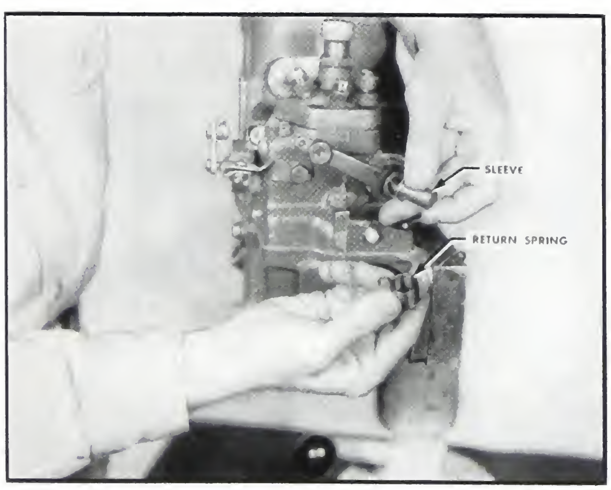


Fig. 5-368. Assemble throttle return spring and sleeve

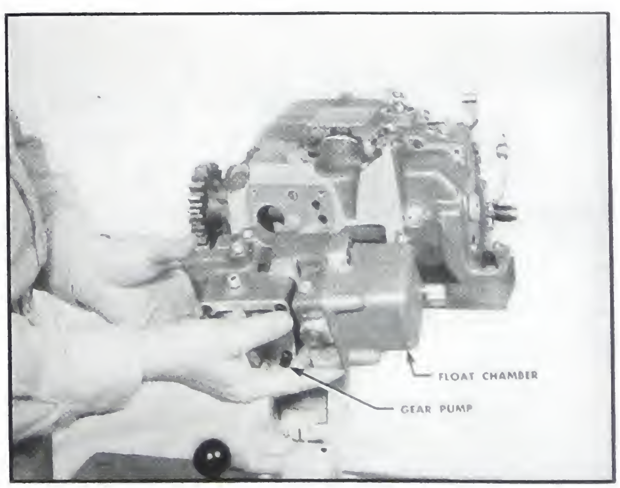


Fig. 5-370. Replace gear pump assembly

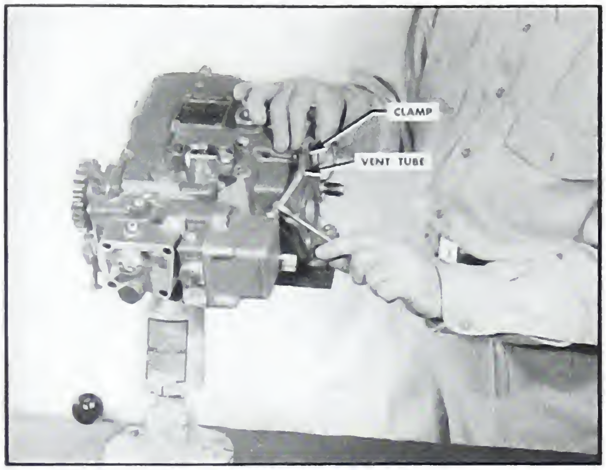


Fig. 5-371. Replace vent tube

GOVERNOR HOUSING COVER: Use a new cover gasket and assemble the cover to the housing with six 1/4"—20 x 1" socket head capscrews, lockwashers and flat steel washers. Use flat steel washers against aluminum. Fig. 5-369.

FUEL PUMP SCREEN: Insert the fuel pump screen and tighten in place. Fig. 5-369.

Float Chamber And Gear Pump Assembly

The float chamber and gear pump assembly is held to the fuel pump main housing by four 1/4"—20 x 3 1/2" socket head capscrews. The float chamber is held to the gear pump by four 1/4"—20 x 2 1/4" socket head capscrews.

1. Using a new gasket or gaskets determined by the operations described in Step 6, Page 5-90, assemble the gear pump to the lower housing with four socket head capscrews, lockwashers and flat steel washers, and tighten securely. Use the flat steel washers against aluminum. Fig. 5-370.

2. Replace the vent tube to the float chamber and upper housing. Fig. 5-371.

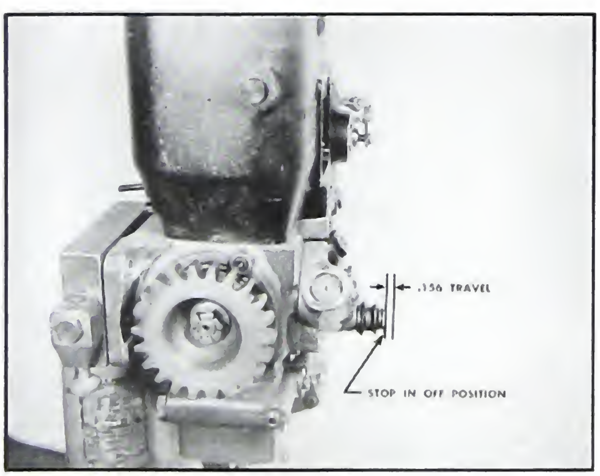


Fig. 5-372. Set overspeed-stop travel

Automatic Overspeed Stop

1. Using a new gasket, assemble the stop to the lower housing.

2. Check the travel of the knob from cocked position to closed position; travel should be .156 inch. If it is not, remove the knob and screw the catch in or out until the proper travel is obtained. Fig. 5-372. See Page 5-84.

Auxiliary Governor Drive

Generally the hydraulic governor is mounted on an auxiliary governor drive unit at the rear of the fuel pump. Fig. 5-173. One model of these drive unit housings also contains the oil sump for the governor but the drive assembly is very much the same. Following are the assembly and disassembly instructions for the auxiliary governor drive.

Repair instructions for the hydraulic governor is given on Pages 5-19 and 5-43.

DISASSEMBLY: 1. Disconnect the oil line from the governor and governor oil sump.

2. Remove the governor levers and linkage if

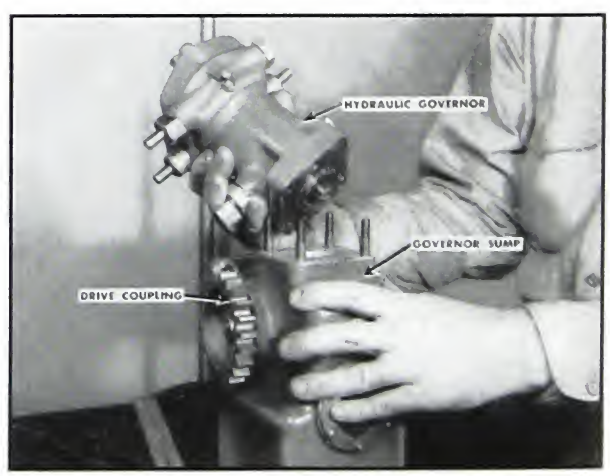


Fig. 5-373. Remove governor

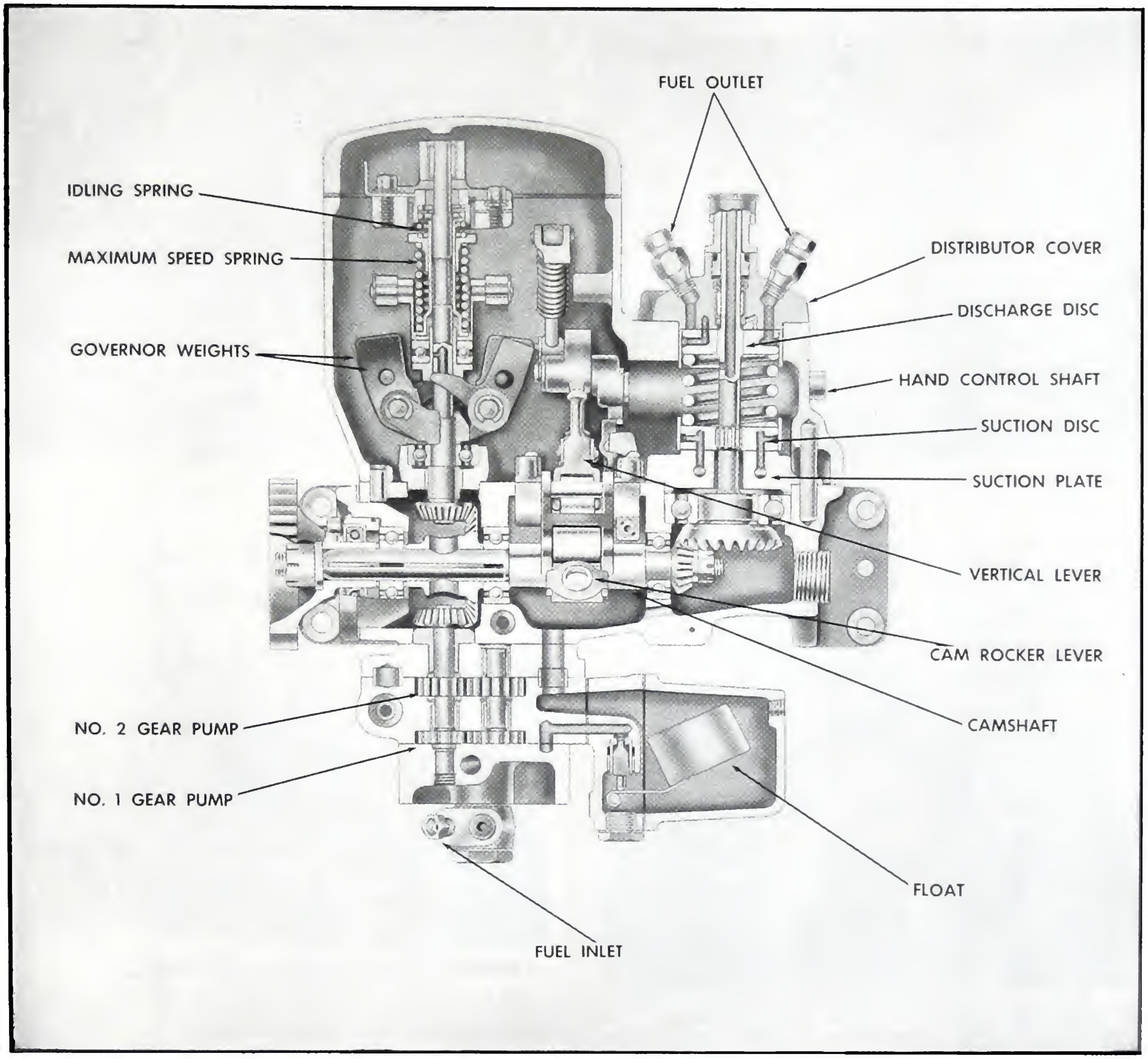


Fig. 5-374. Cross section—DD fuel pump

not removed.

3. Loosen the four governor to drive assembly stud nuts and lift the governor from its mounting. Fig. 5-373.

4. Lift out the governor drive collar. Fig. 5-375.

5. Remove the nut and washer and pull the governor drive half coupling.

6. Remove governor driven shaft snap ring.

7. Take out the sump drain plug and use a long punch to drive out the governor driven shaft assembly. Fig. 5-378.

8. Lift out the governor drive coupling key.

9. Drive out governor drive shaft assembly and expansion plug. Fig. 5-378.

10. Remove coupling oil seal, drive shaft bearing and snap ring.

11. Drive out the driven shaft needle bearing.

12. If necessary, remove the ball check valve and spring, beneath the fitting at the bottom of the sump. Fig. 5-379.

INSPECTION AND REPAIR: 1. Inspect the gears for broken teeth or excessive wear.

2. Wash bearings in mineral spirits and check for worn or rough races.

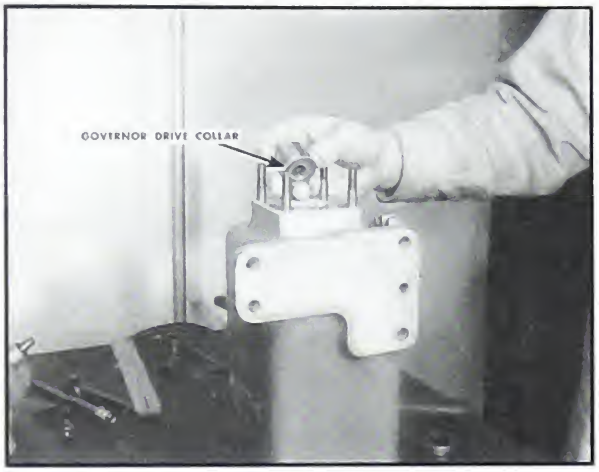


Fig. 5-375. Lift out governor drive collar

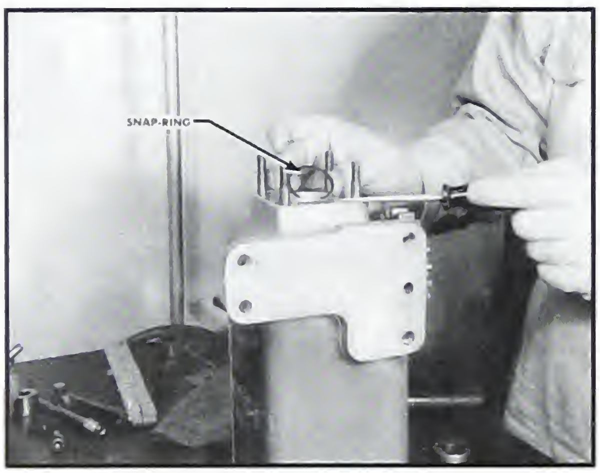


Fig. 5-376. Remove driven shaft snap-ring

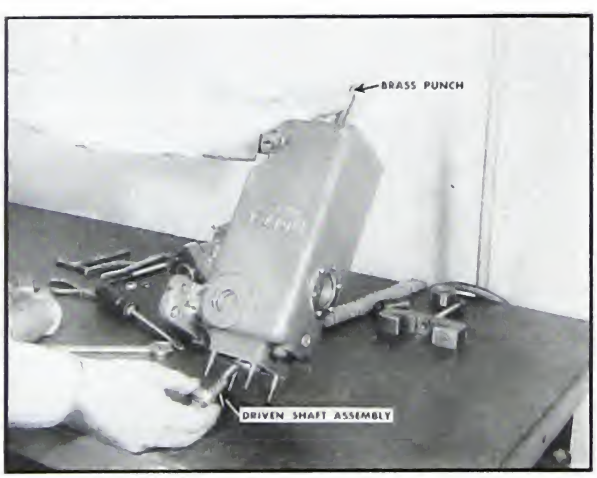


Fig. 5-377. Drive out driven shaft

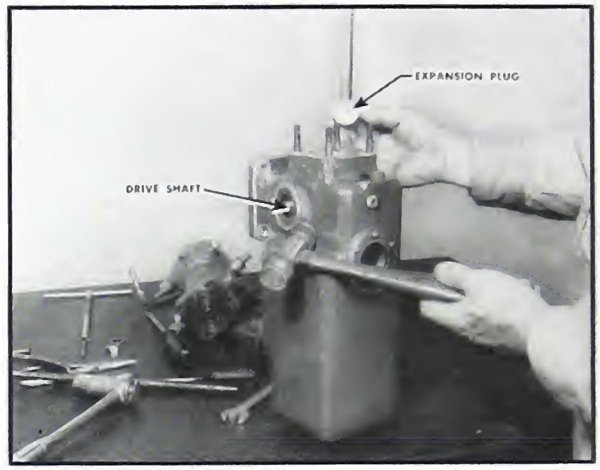


Fig. 5-378. Drive out drive shaft

3. Bearings and gears may be pressed from shafts after removal of the snap rings that hold them in location.

ASSEMBLY: 1. Press large drive bearing into sump housing. Fig. 5-380.

2. Assemble snap ring in its groove and press oil seal in position with sealing lip in.

3. Drive driven shaft needle bearing into the housing. Fig. 5-381.

4. Drive the drive shaft assembly in position. Drive with care to avoid damage to the large bearing and oil seal that were pressed in the housing previously. Fig. 5-382.

5. Replace half-coupling drive key.

6. Press on the half-coupling and tighten in position with flat washer and nut.

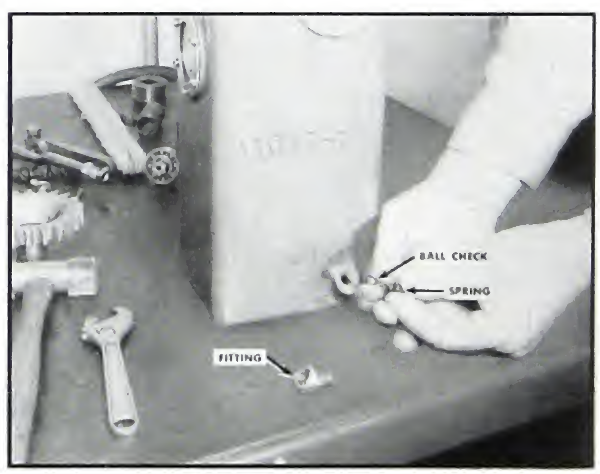


Fig. 5-379. Ball check valve

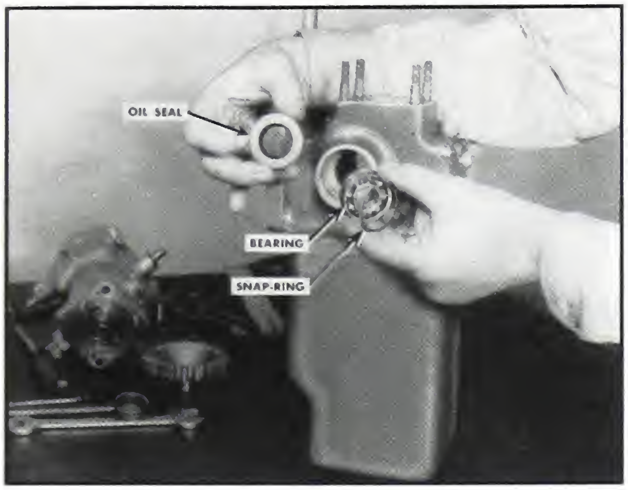


Fig. 5-380. Assemble bearing, snap ring and oil seal

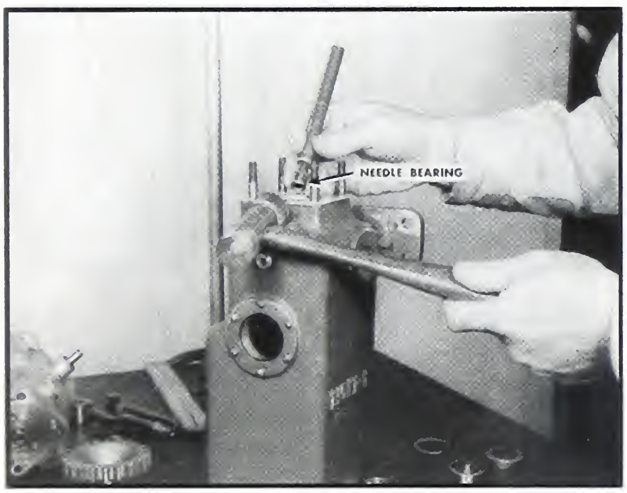


Fig. 5-381. Replace needle bearing

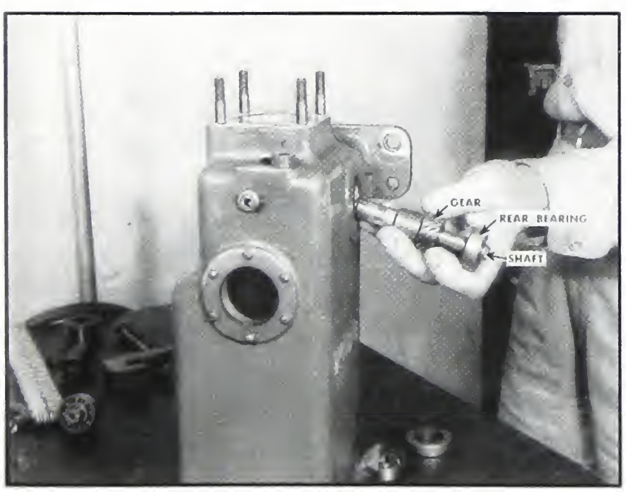


Fig. 5-382. Replace drive shaft

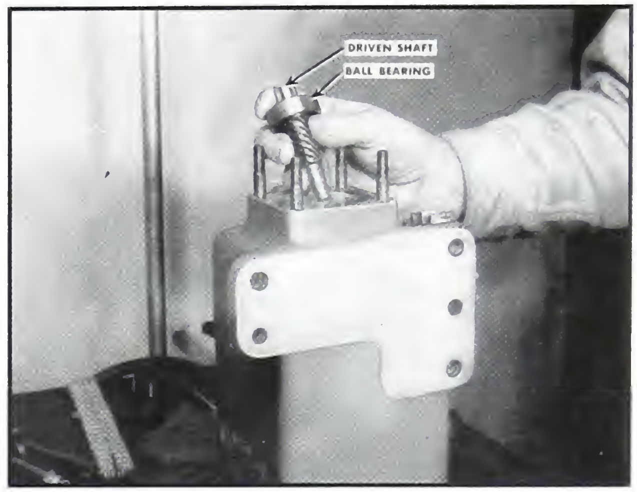


Fig. 5-383. Replace driven shaft

7. Drive in expansion plug.

8. Insert driven shaft assembly and drive in position. Rotate drive shaft during this operation to insure engagement. Fig. 5-383.

9. Replace driven shaft assembly snap ring.

10. Place coupling collar over splined end of driven shaft.

11. Replace gasket and position governor over the studs and tighten in position.

FUEL PUMP TESTING AND CALIBRATING

THE TEST STAND: 1. Any fuel pump test stand used to test and calibrate Cummins fuel pumps should be equipped with the following features.

A. Fuel oil and lubricating oil supply tanks with filters to insure cleanliness.

B. A minimum 3 hp electric motor connected to a fuel pump drive by means of a variable speed drive that will provide for speed ranges from 250 for L pumps to 2500 rpm for NH pumps. The motor and drive must be reversible.

C. A hydraulic gauge to register fuel pump pressure to the distributor.

D. A hydraulic gauge to register fuel pressure from the metering pump.

E. An auxiliary motor or drive from the power shaft to a small lubricating oil pump, and drain lines to provide lubricating oil for single-disc governor lubrication.

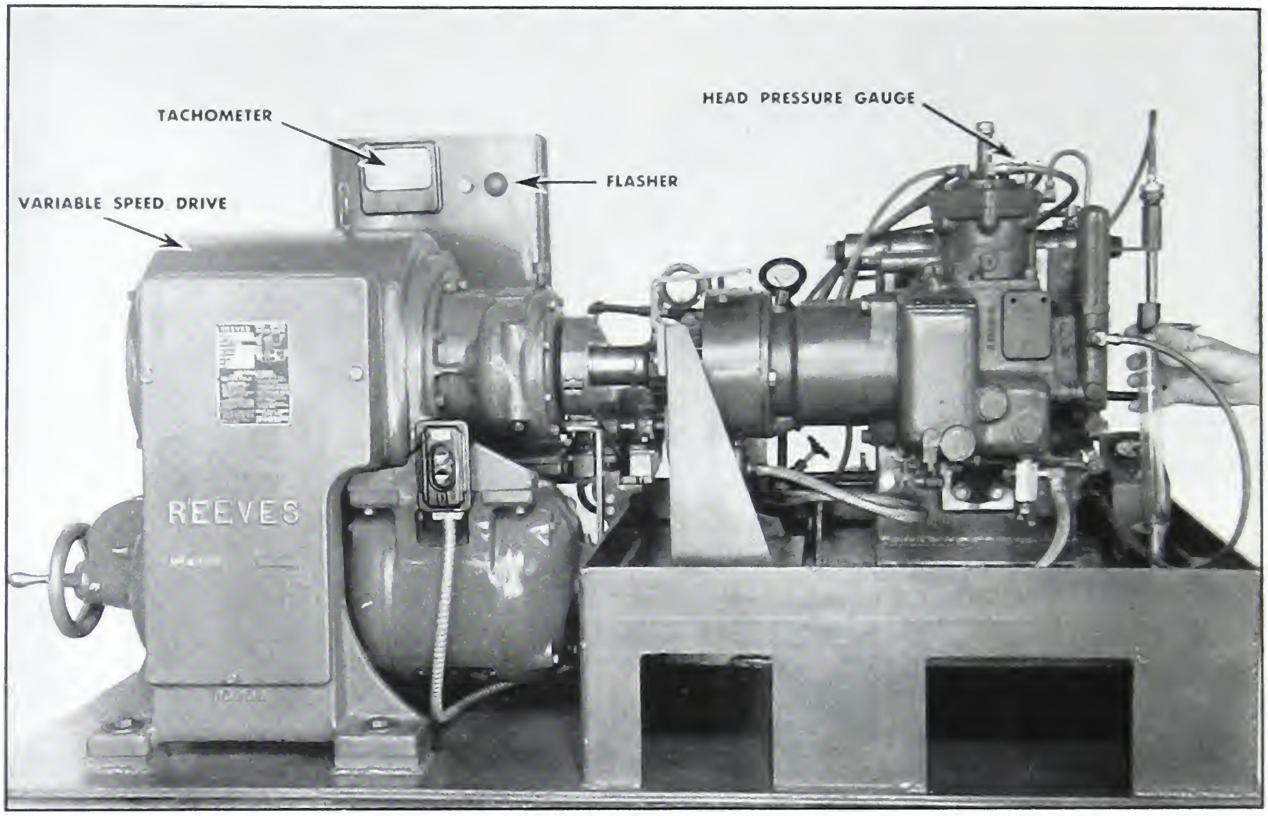


Fig. 5-384. ST-273 fuel pump test stand

F. Fuel inlet connections and orifices from which the metered charge is collected from the six fuel supply lines from the distributor. The inlet connections and special orifices are necessary to duplicate, as nearly as possible, factory test procedures.

NOTE: The lubricating oil pump must be suited to either right or left hand rotation.

G. A tachometer to register fuel pump drive shaft speed.

H. A revolution counter to register the revolutions of the fuel pump drive shaft. This should be equipped with a bell or flash signal for each 500 revolutions to insure accuracy in collecting the fuel.

I. A glass graduate with cc calibrations.

J. A pressure gauge attached to a manifold which can be cut in to measure head pressure.

K. Fuel lines and connections as shown in Fig. 5-385 and Fig. 5-386.

2. ST-273 is a test stand that will meet all the above specifications. Fig. 5-384.

CONNECTIONS: 1. Install the pump on the test stand with the proper adaptor and fuel lines for the model pump being tested. Connect fuel tubes to corresponding fuel inlet connections and test injectors.

2. Check to be sure that:
   a. Emergency control valve is OPEN.
   b. Priming valve is CLOSED.
   c. Overspeed stop, if used, is in RUNNING POSITION.

3. Connect the fuel inlet plug connection to a source of clean fuel oil that will meet recommended fuel oil specifications.

4. Connect a priming pump to the priming pump connections and fuel pressure gauge. Pump the fuel pressure to 80 or 90 pounds on the fuel pressure gauge.

CHECK TIMING—Single-Disc: 1. Remove the fuel cam rocker lever retainer and spring and install indicator gauge and attachment, ST-356, with fuel pump turned to assembly position so the timing mark on distributor drive collar shows through the peep hole of the distributor disc. Set

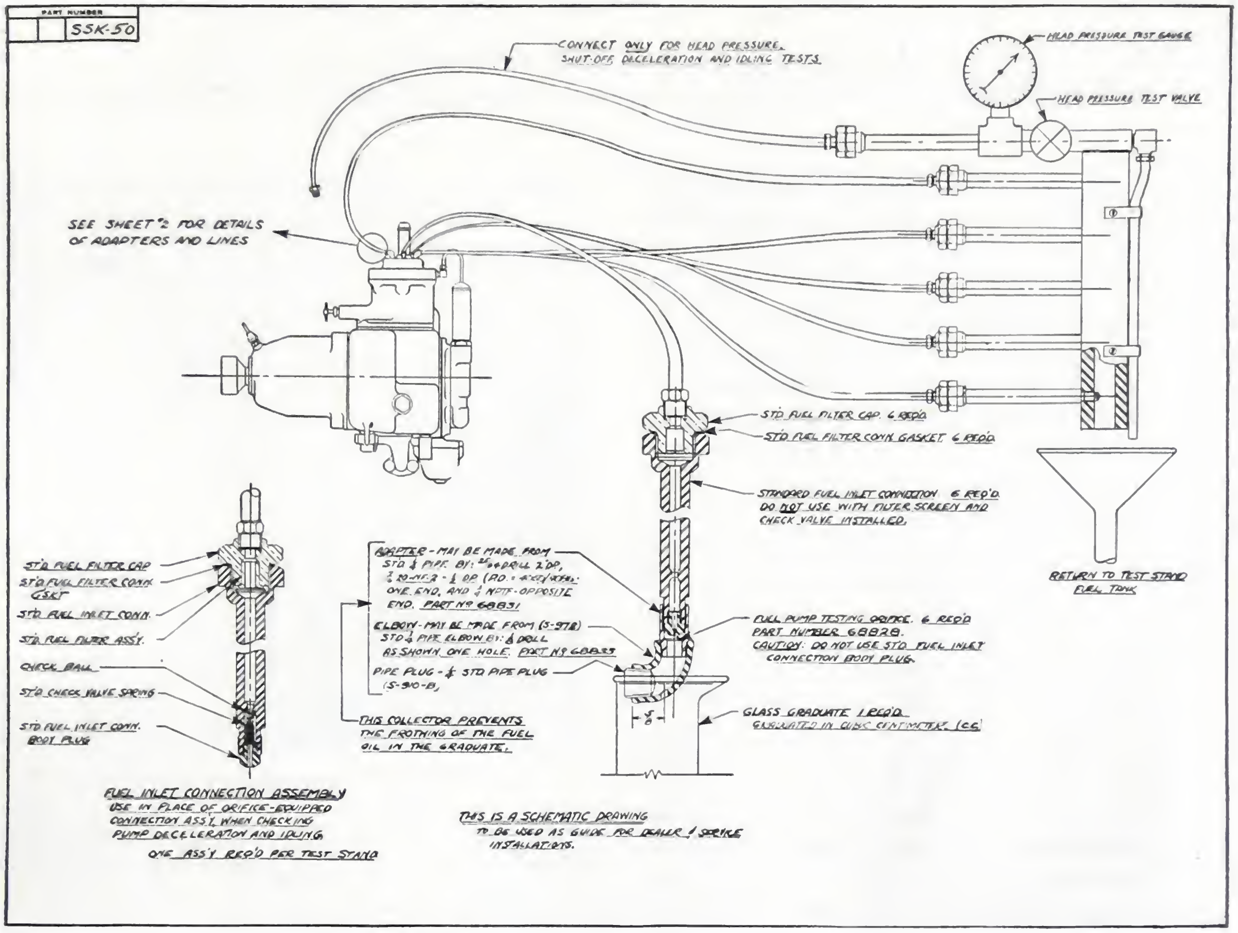
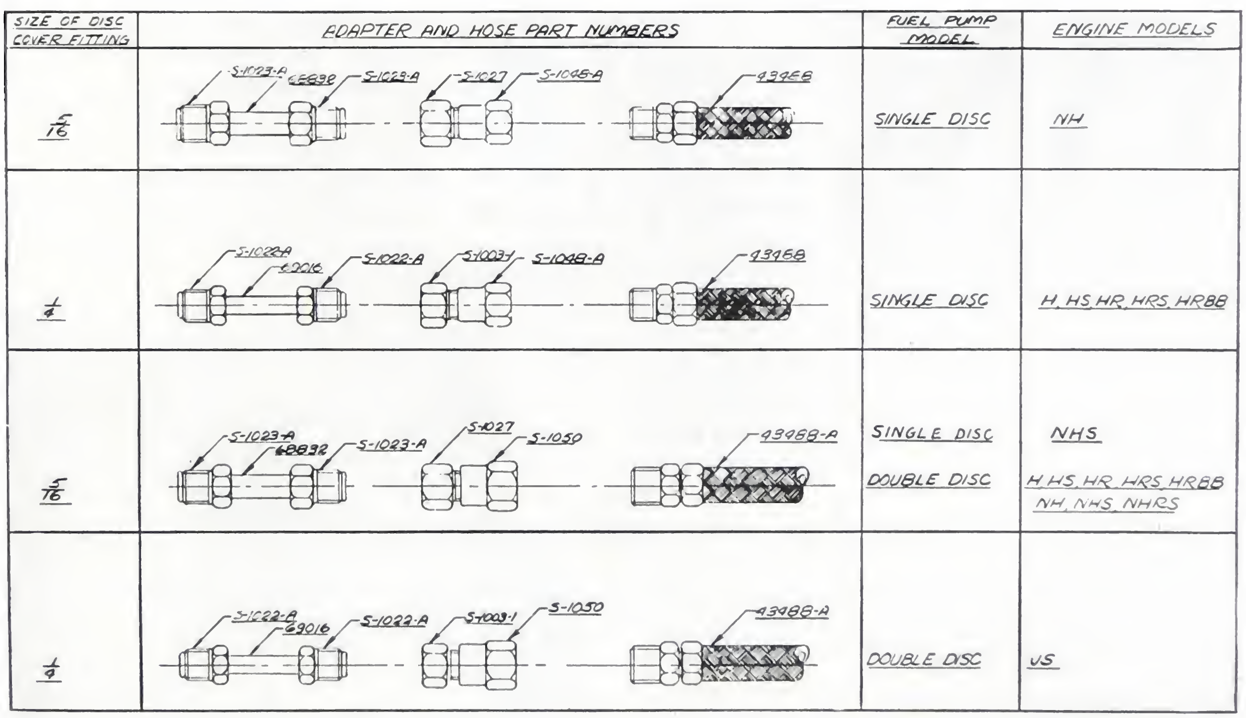


Fig. 5-385. Fuel pump test stand (connection assembly)



SIZE OF DISC COVER FITTING	ADAPTER AND HOSE PART NUMBERS	FUEL PUMP MODEL	ENGINE MODELS
5/16	S-1023-A, 68832, S-1023-A, S-1027, S-1048-A, 43968	SINGLE DISC	NH
1/4	S-1022-A, 69016, S-1022-A, S-1003-1, S-1048-A, 43968	SINGLE DISC	H, HS, HR, HRS, HRBB
5/16	S-1023-A, 68832, S-1023-A, S-1027, S-1050, 43968-A	SINGLE DISC DOUBLE DISC	NHS H, HS, HR, HRS, HRBB, NH, NHS, NHRS
1/4	S-1022-A, 69016, S-1022-A, S-1003-1, S-1050, 43968-A	DOUBLE DISC	VS

NOTE:
USE ONLY THE STANDARD ADAPTERS AND LINES. DO NOT USE ANY ADDITIONAL FITTINGS OR MORE THAN ONE ADAPTER PER LINE.

Fig. 5-386. Fuel pump test stand (adapters and hose)

indicator gauge at "0". Turn the mainshaft in its operating direction until the gauge shows a rise of .0015.

2. Open the priming valve and operate the priming pump. Fuel should flow from No. 3 distributor outlet on RH 6 cylinder pump or No. 2 outlet on LH pump. In other words, priming position is always two cylinders ahead of firing position. On four cylinder RH or LH pumps this will be No. 4 outlet open for priming.

3. Turn the main shaft until the indicator gauge shows that the cam rocker lever roller is in contact with the highest point of the cam lobe. Again operate the priming pump. Fuel should continue to flow from the same distributor outlet.

4. If fuel priming passage is not open for positions indicated in preceding Steps 6 and 7, (1) the distributor collar is not properly assembled to the shaft, or (2) distributor gear and drive gear are not properly assembled, or (3) the proper distributor disc is not being used for the pump.

5. Close the priming valve.

6. Remove gauge and attachment and install spring and retainer.

NOTE: Refer to Pages 5-102 and 5-103 for DD pump timing.

FUEL PRESSURE: 1. Connect the loose fuel lines to distributor cover.

2. Connect the distributor outlet connections to the injector inlet connections. See Fig. 5-386.

NOTE: The inlet connections must have ball checks removed, and they must be equipped with No. 68828 orifice plug as shown in Fig. 5-386.

3. Clamp the hand throttle lever in full fuel position.

4. Check to see that the governor sump of hydraulic type pump is filled to the proper level with clean SAE 20 lubricating oil. Start the lubricating oil pump, if testing a mechanical type pump.

5. Turn on the motor and run the fuel pump at 500 to 1000 rpm for 5 or 10 minutes. During this time, check to see that the gear pump assembly does not heat up and that the distributor drive gears, overspeed stop drive gears and governor drive gears are not noisy. If they are noisy it is an indication of improper gear lash and must be corrected at once to avoid ruining the gears.

HEAD PRESSURE: 1. Divert the fuel from one distributor outlet to a dead end against the head pressure gauge by connecting the one fuel line from the head pressure gauge to one distributor outlet. As pressure builds up in the fuel line, the gauge hand will advance to show maximum head pressure, or the pressure at which the distributor disc and cover separate.

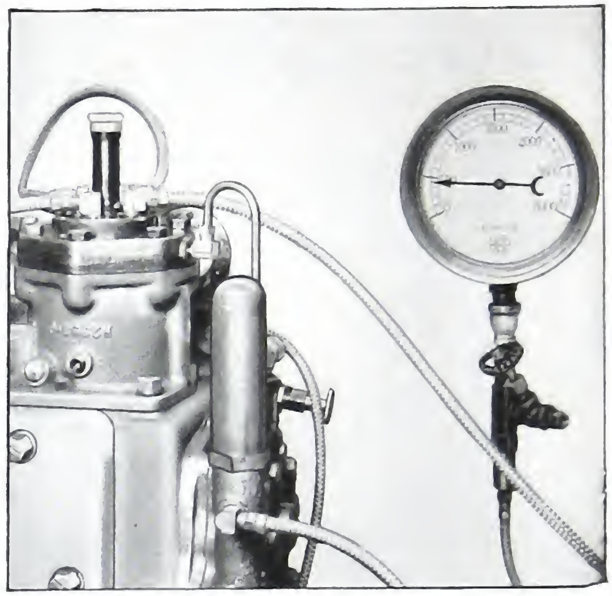


Fig. 5-387. Checking fuel pump head pressure

2. As soon as the maximum pressure is indicated, open the relief valve and shut off the test motor.

3. Minimum satisfactory head pressures at 1000 rpm for new or rebuilt single-disc pumps, and fuel pressures at 500 rpm; DD pumps are listed with their respective rpm.

TEST PRESSURES

	Head Pressure		Fuel Pressure	
	Single-Disc	DD	Single-Disc	DD
H	450	All	120-130	
HS	550	Engines	135-145	All
HR				
HRS		450 lbs.		Pumps
NH	550	@	135-145	
NHS	550	1000 rpm	155-165	118
NHRS				to
HRBB				128 psi
A	400			
JS				
L-LR	800		170-180	

MAXIMUM FUEL SETTING DD FUEL PUMP: The maximum fuel is adjusted by the maximum-fuel adjusting screw. Check maximum fuel delivery with the hand control at full-throttle and with the pump turning at rpm shown. The check is made by collecting the fuel delivered from one .020 inch orifice outlet during 500 revolutions of the fuel pump. Adjust the pump to deliver according to the following table. Variation should not exceed 5%.

MAXIMUM FUEL DELIVERY AT RATED SPEED:
(D-D Fuel Pump)

Model Engine	cc per 500 Revolutions	@ rpm
H	25	1800
HR	30	1800
HS	39	1800
HRBB	30	2000
HRS	43	2100
NH	31	2100
NHH	33	2100
NHS	44	2100
NHRS	50	2100
JS	27	2500

These settings are for engine operation to 1000 feet altitude. Reduce fuel delivery 3% for each 1000 feet additional altitude.

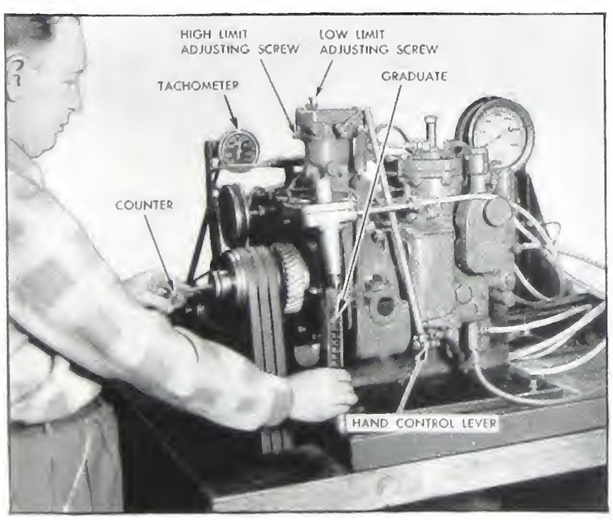


Fig. 5-388. Calibrating the fuel pump

SINGLE-DISC FUEL PUMPS: 1. During 500 revolutions of the pump, as shown by the revolution counter, collect the fuel oil delivered from one orifice. Adjust the maximum fuel delivery set screws until the pump delivers, at its maximum rated speed, the proper amount of fuel per outlet as shown for the model pump.

2. The variation of fuel delivered at each outlet must not exceed 5%.

Single-Disc Pumps

Engine Model	CC/Injector/500 Rev. @ Full Load RPM	Full Load RPM
H	28	1800
HS	41	1800
HR	34	1800
HRS	41	1800
HRBB	31	2000
NH	33½	2100
NHS	52	2100

3. These settings are for engine operation to 1000 feet altitude. For each 1000 additional feet altitude the fuel setting should be reduced 3%.

4. Maximum fuel delivery for Model L pump can not be adjusted on the test stand.

FUEL LEVEL: 1. A fuel level inspection tube should be screwed into the float chamber drain outlet and fuel level in float chamber checked while running the pump. The float chamber should be from 2/3 to 3/4 full of fuel at all times to insure an adequate fuel supply, but at the same time it must have space to receive fuel from the main housing that has been used for lubrication for both pumps.

2. The fuel level in the float chamber can be changed by adjusting the float or by changing the tension of the fuel by-pass valve spring.

Low fuel level indicates sticking by-pass, sticking float valve, insufficient float valve travel, or float lever hitting bottom of housing.

High level or fuel flowing out injector drain connection indicates float valve not seating, float valve sticking, float lever hitting top of housing, worn cam rocker lever bracket bushings and scored discs.

GOVERNED SPEEDS: 1. Turn the hand control lever to full throttle position and secure with a clamp.

2. Operate the fuel pump at its maximum rated speed. This speed is indicated by the last four numbers on the side of the main housing. "1200," "1600," "1800," etc. If the governor starts to close off the fuel delivery at any other than the maximum rated speed, it indicates that a speed adjustment is needed on the governor.

3. Governor speed adjustment on mechanical governors can be made only by changing maximum speed spring weight combinations.

4. Actual governor shut-off can be detected by visual inspection with the distributor housing off the pump and while running the pump in its top speed range. Fuel oil must be allowed to pour from the gear pump into the main housing for lubrication.

A special bracket must be provided to hold a metering pump and link in position to simulate working conditions for the vertical lever and plunger lever during this test.

HYDRAULIC GOVERNOR—Single-Disc Fuel Pumps: 1. The Woodward SG governor used on some single-disc pumps is of the hydraulic type using lubricating oil under pressure as an energy medium. It is supplied from a sump on the governor drive housing.

2. The governor acts through oil pressure to increase fuel delivery. An opposing spring in the governor control linkage acts to decrease fuel delivery.

3. In order that its operation may be stable, speed droop is introduced into the governing system. By speed droop is meant the characteristic of decreasing speed with increasing load. The desired magnitude of this speed droop varies with engine applications and may easily be adjusted to cover a range of approximately one-half of one per cent to seven per cent.

4. The hydraulic feature is brought about by oil from the sump being admitted to a gear pump in the governor base. The gear pump raises the oil pressure to a value determined by the relief valve spring opposing the relief valve plunger. When the governor is operating, the oil is maintained under pressure in the annular space between the reduced diameter on the pilot valve plunger and its working barrel.

5. For any given speed adjustment setting, the speeder spring has a definite compression. This

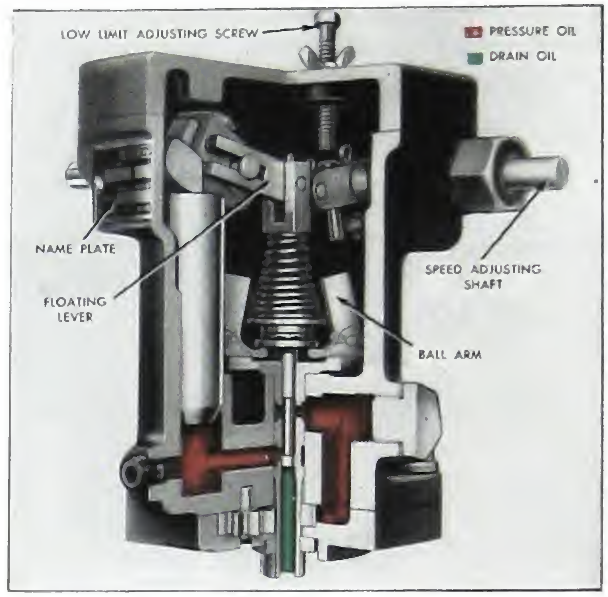


Fig. 5-389. Load on, speed decreased position

must be opposed by the centrifugal force of the flyballs. When these two forces are in equilibrium, the land on the pilot valve plunger exactly covers the lower holes, or ports, in the barrel. Under a steady load condition, speed will then remain constant. (Fig. 5-389).

6. Assume that a certain amount of load is applied to the engine. The speed will drop, the flyballs will be forced inward and will lower the pilot valve plunger. This will admit oil pressure underneath the power piston, which will rise.

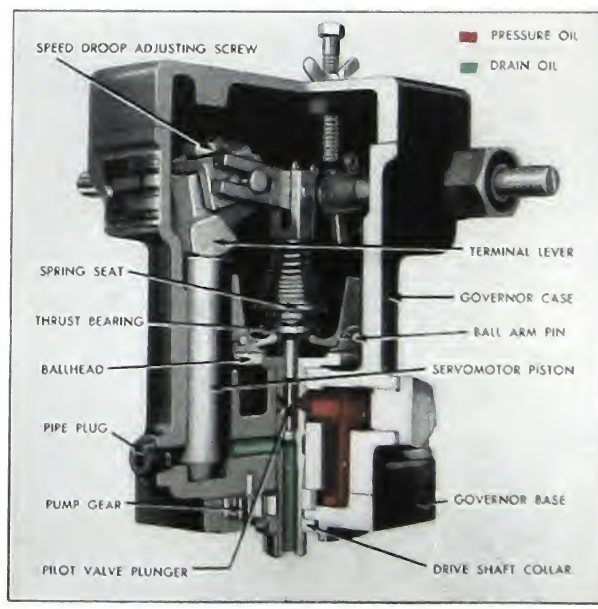


Fig. 5-390. Load off, speed increased positon

The movement of the power piston is transmitted to the terminal shaft by the terminal lever. Rotation of the terminal shaft causes the fuel setting on the engine to be increased. (Fig. 5-390).

7. Simultaneously with the upward movement of the power piston, the droop rivet on the droop adjusting bracket moves upward and raises the floating lever which pivots about the spring fork pin in the speed adjusting lever.

8. When a load is applied, the engine speed drops slighty; and, as a consequence, the centrifugal force of the flyballs decreases. As the floating lever rises, the compression load on the speeder spring is reduced and enables the flyballs to assume again their normal vertical position.

9. The land on the pilot valve plunger again exactly covers the ports in the barrel and the power piston stops moving at a position corresponding to an increased fuel setting on the engine. The engine now carries the increased load at a slightly reduced speed because of the slight decrease in the speeder spring compression.

10. If the governor is to be used for constant speed service, speed adjustment may be made by setting the low limit adjustment screw. Rotation of the speed adjustment shaft increases or decreases the compression on the speeder spring.

11. Rotating the speed adjusting shaft sufficiently far in the decrease speed direction opens the area under the power piston to drain and enables the fuel return spring to shut off the fuel completely, thus shutting down the engine.

OVERSPEED TRIP: To test the automatic overspeed trip on single-disc or double-disc pumps increase the speed of the fuel pump until the overspeed stop trips. It should trip at about 15% overspeed.

CAUTION: SLOW DOWN THE FUEL PUMP AND RESET THE OVERSPEED STOP IMMEDIATELY TO AVOID SCORING THE DISC AND COVER.

Fuel Filters

Any one of three fuel filters may be used on H and NH series engines. Directions for complete servicing of each of these filters are given in succeeding paragraphs.

It is to be borne in mind that dirty filters or elements are practically useless in the fuel sys-

Fig. 5-391. Commercial Fulflo Fuel Filter

tem. Although suggestions are made for periodic servicing, the periods must vary with engine load (fuel consumption) and quality of fuel. As soon as a fuel filter gets dirty it restricts fuel flow in varying degrees. *At full fuel consumption the restriction from dirty filter elements may be great enough to cause the fuel by-pass in the fuel pump housing to open from suction of the No. 1 gear pump and interfere seriously with engine power.*

COMMERCIAL FULFLO FUEL FILTER: 1. The Fulflo filter consists of a filter shell and a filter base, upon which the filter tube and sealing plates are mounted. By means of a locking ring on the base of the single tube filter the shell is attached and the filter tube is locked into position.

2. Filter tube life is determined by the amount and nature of the solids in suspension. Replace the filter element assembly each 2,000 gallons fuel consumed, or more often in case of severe operating conditions, to insure maximum protection.

3. To replace the filter element assembly proceed as follows:

4. Remove vent plug and drain screw and drain shell of fuel oil. Be sure to tighten drain screw securely after draining.

5. Remove the hex cover nut on the filter and drop the shell.

6. Empty the shell of any unfiltered fuel, remove, and dispose of the used element. CLEAN THE CASE THOROUGHLY.

7. Insert a new filter element in the shell, making sure that the filter core is placed over the bottom core sleeve to center it on the seal ring.

8. Before replacing shell, remove the old filter head gasket and replace with the new gasket furnished with the assembly.

9. Reassemble the shell to the head so that the filter core at the top of the filter tube slips over the top core sleeve. Be sure that the filter head engages the shell evenly all around and tighten the hex cover nut.

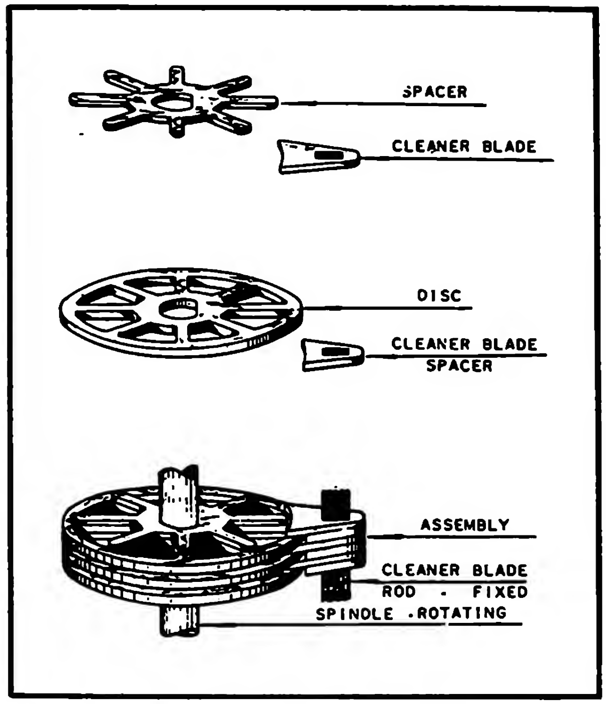


Fig. 5-392. Cuno filter element

NUGENT FUEL FILTER: 1. The Nugent fuel filter is commonly referred to as a bag type filter. It is a full flow filter with no by-pass. (This differs from the Nugent lubricating oil filter which has a built-in by-pass valve).

2. The bag for this filter is made of wool. It is wrapped around a spacer mat to give greater filtering capacity. The bag should be changed for each 2,000 gallons fuel consumed, or more often, if needed.

3. Remove the cover and lift the filtering element from the case. Remove the old bag from the spool and throw the bag away. NEVER ATTEMPT TO WASH FILTER BAGS.

4. Clean the case and all other parts (except the bag) thoroughly in non-corrosive solvent. Rinse with clean fuel oil and dry with compressed air.

5. Replace gaskets.

6. Inspect the spool and clamp and replace if not in good condition.

7. Install the new bag as shown in Section No. 7 "Changing Nugent Lubricating Oil Strainer Bags".

8. Replace the assembled element in the case and assemble the case with new gaskets in place.

CUNO FUEL FILTER: 1. The Cuno fuel filter is a strainer type. Fig. 5-392 shows the essential parts of the cartridge. (Vertical dimensions are exaggerated for greater clarity.) The stack of discs and spacers is closed at one end, the opposite end being connected to the filter discharge. Thus all fluid, in order to pass the filter, must go through the slots between the discs. When the assembly of discs and spacers is turned by means of the rotatable spindle, solids that have lodged against the disc, or between them, are carried around until they meet the cleaner blades. The blades are held in position by the fixed cleaner blade rod, and are cleaned clear of the filter surface.

2. In ordinary service the filter is cleaned by giving the external handle one complete turn. This rotates the cartridge past the stationary cleaner blades which extend into the slots between the discs. Accumulated solids are combed out and fall to the sump.

3. If the handle has stuck, and at engine overhaul periods, remove the cartridge from the case and wash case and cartridge thoroughly in solvent.

SECTION VI

UNIT NO. 6

Fuel Tubing, Connections And Injectors

The entire fuel system consists of the fuel supply tank, filters, tubing, the fuel pump, inlet and drain connections and injectors.

The fuel pump, treated in Unit No. 5 Section, draws fuel from the fuel supply tank through tubing and filters, meters it in equal charges and delivers, at the proper time, the metered charges of fuel, at low pressure, through tubing and inlet connections to the injectors. Fuel used by the injectors for lubrication drains back to the fuel pump through drain connections and tubing.

All fuel delivery lines remain full of fuel at all times. Fig. 6-1.

Injectors force, at high pressure and at the proper degree of crankshaft travel, the metered charges of fuel into the combustion chamber for the power stroke.

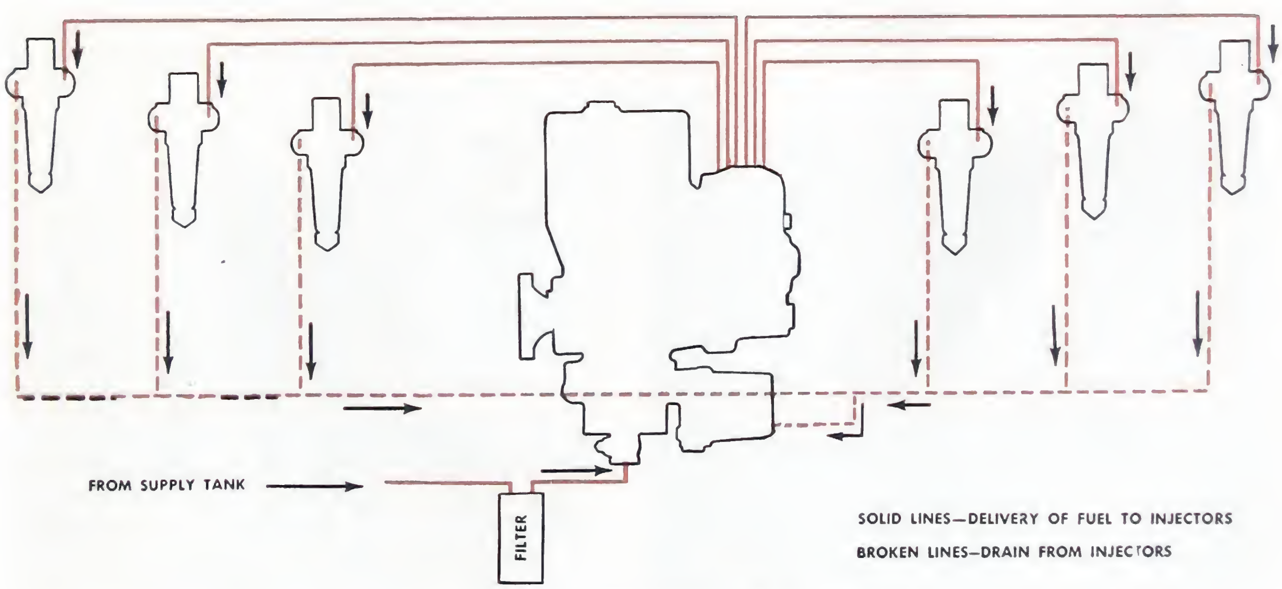


Fig. 6-1. Fuel piping diagram

CLEANING DISASSEMBLY AND INSPECTION

Clean injectors externally and all tubing and connections in a tank of mineral spirits.

Fuel Tubing

Reject any fuel tubing or tubing connections: (1) that are not standard size or length, (2) that are twisted or bent out of shape or (3) that have damaged threads.

Inlet Connections

1. There are two check valves in the fuel line between the fuel pump and the injector cup. One is in the injector fuel inlet connections.

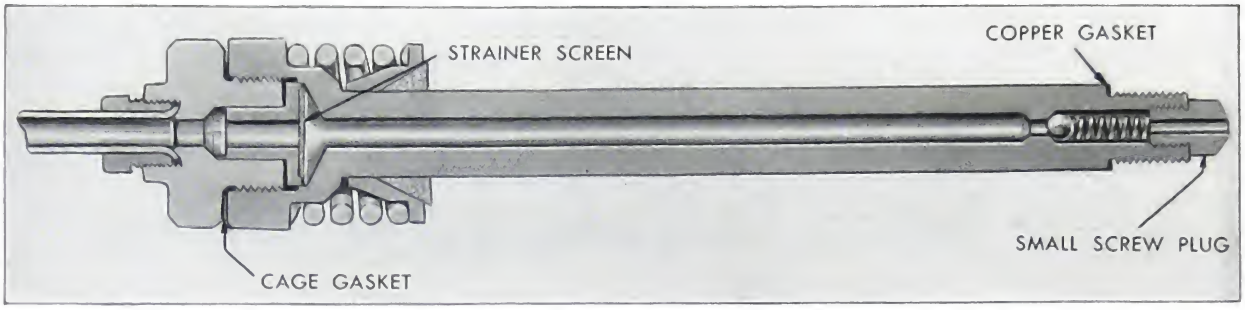


Fig. 6-2. Injector fuel inlet connection

2. The check valves are opened by fuel pressure from the metering pump and are closed when pump delivery is finished. The operation of the injector fuel inlet connection valve is very important. It must be checked accurately for leakage and breaking point.

3. The check valve should break at not less than 45 pounds and at not more than 55 pounds fuel pressure. This can be checked by applying fuel pressure from a priming pump, or it can be checked on the injector test stand, ST-272.

4. Screw the connection into the adapter provided on ST-272 and apply back pressure test of 2000 psi. If it leaks, tag for correction, either by reseating or replacement.

5. Disassemble the connection and clean the strainer screen.

6. Inspect the threaded end of the connection. Damaged threads will cause fuel leakage and damage the mating threads in the injector body.

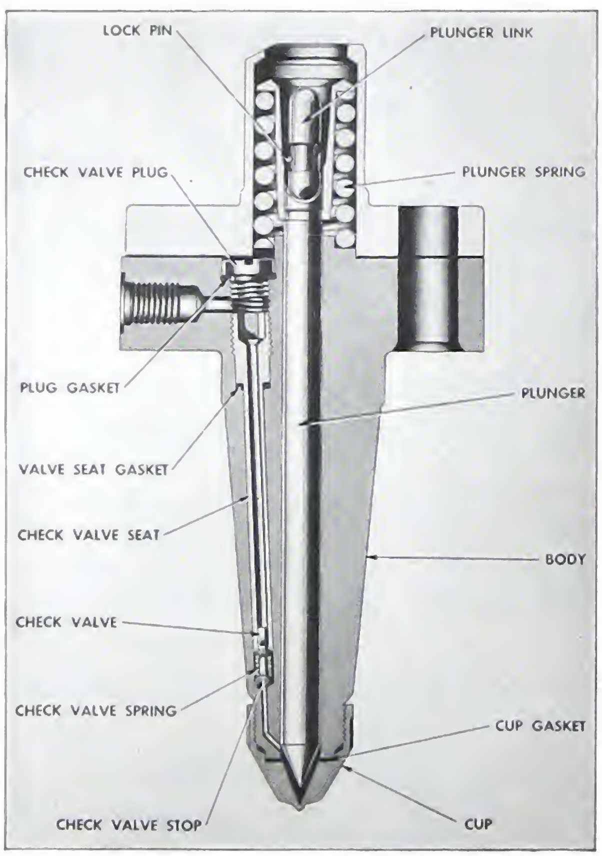


Fig. 6-3. Standard type injector

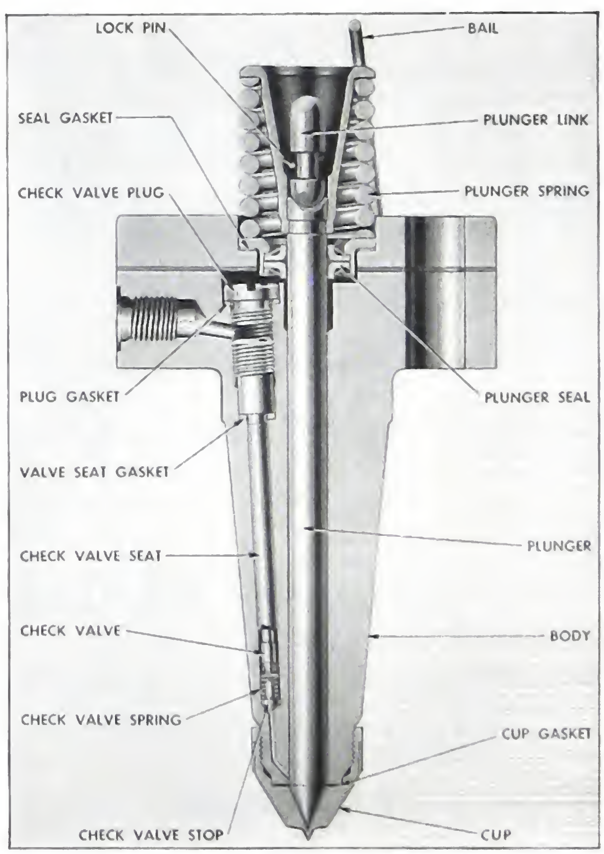


Fig. 6-4. Tractor type injector

Injector

1. Cummins manufactures and supplies two injectors. They differ only in the manner in which the injector plunger is sealed to prevent mixture of fuel and lubricating oil. The standard type injector has a top housing and cover. The tractor type injector uses a plunger seal instead of the top housing and cover to prevent fuel oil from getting past the drain to cause crankcase dilution. See Fig. 6-3 and 6-4.

2. In general, the tractor type injector is used only on installations where the engine operates all, or a part, of the time at severe angles. In such cases, some of the fuel oil might drain from the top cover of the standard type injectors and into the crankcase to dilute the lubricating oil.

3. In the standard injector, fuel oil that comes up past the plunger for plunger-body lubrication is caught by the top plate or cover. A drilled hole in the top plate connects with a drilled hole in the body that leads to the fuel drain connection. The fuel drain connection screws into the left hole of the injector body. From the drain connection this fuel oil drains back to the fuel pump where it is again picked up and recirculated to burn as fuel, as shown in Fig. 6-1.

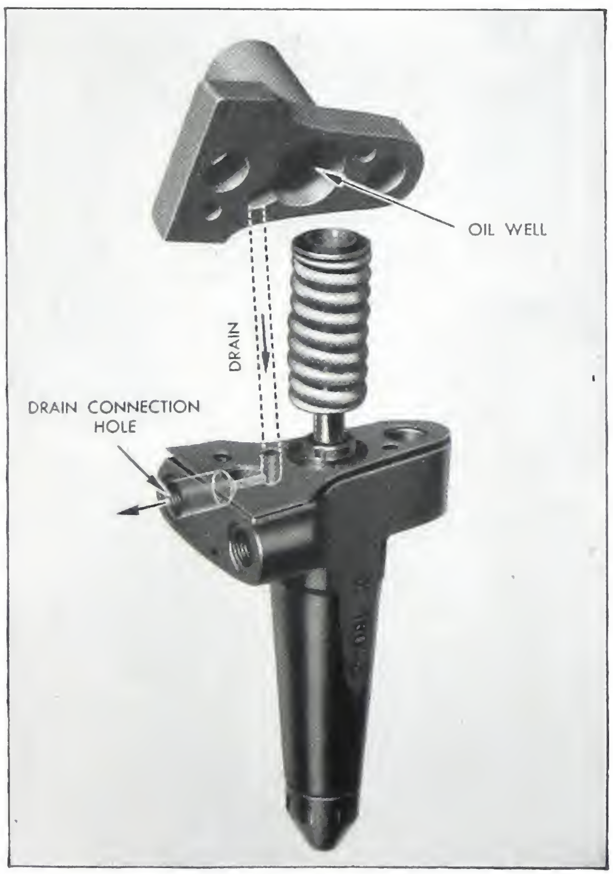


Fig. 6-5. Standard type injector drain

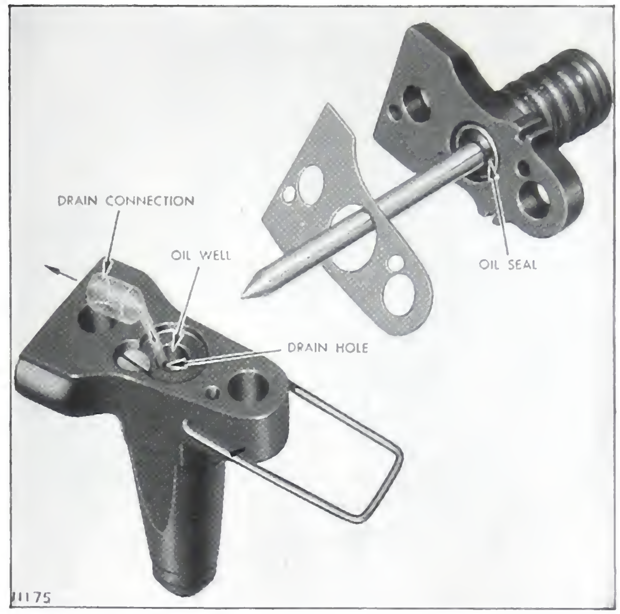


Fig. 6-6. Tractor type injector drain

No top plate or cover is used with the tractor type injector. The body is counterbored slightly to form a well where fuel can accumulate below the plunger seal and pass out of the injector drain hole. This well and passage is indicated in Fig. 6-6.

4. While servicing the injector, never clamp the body in a vise. Clamping in a vise usually causes distortion of the body and ultimately a sticking plunger. Use a fixture similar to ST-111 shown in Fig. 6-7.

5. Place the injector in the holding fixture with the top housing up.

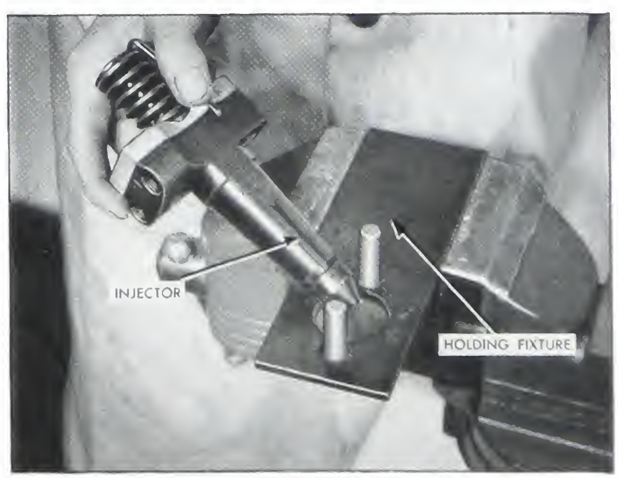


Fig. 6-7. Injector holding fixture

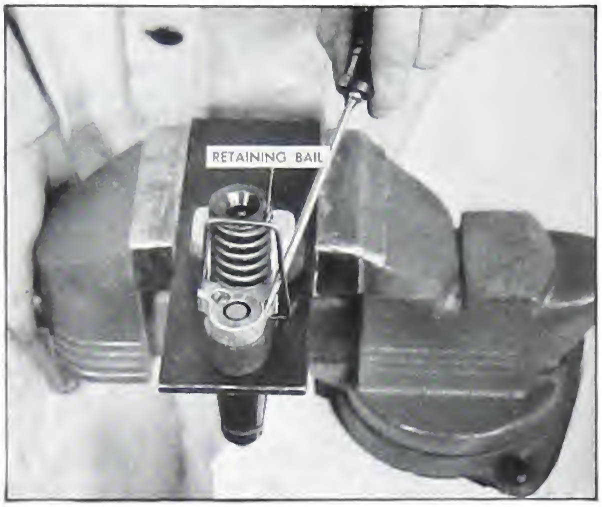


Fig. 6-8. Removing plunger retaining bail—Tractor type injector

6. With a screwdriver, pry the injector plunger retaining bail from the body. (Fig. 6-8).

7. Pull the plunger seal and spring from the body.

8. Remove the cover gasket.

9. If the injector is standard type, remove the fillister head screws and remove the injector top housing. (Fig. 6-9).

10. Pull the plunger from the body.

11. Remove the cover gasket.

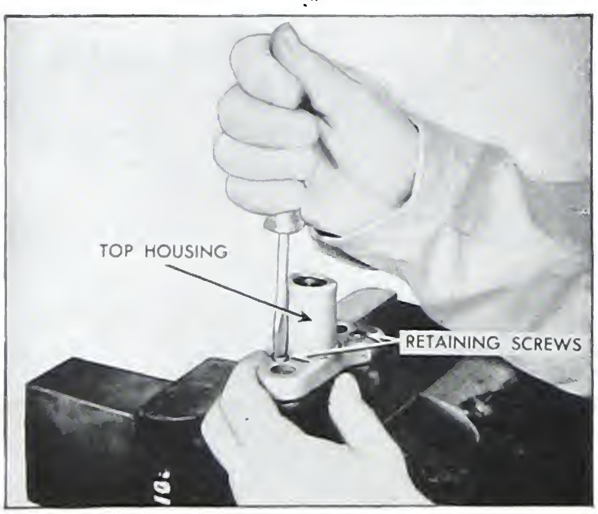


Fig. 6-9. Removing top housing

12. With a large screwdriver, remove the body plug.

13. With an Allen wrench, remove the injector check valve and seat. (Fig. 6-10).

14. Turn the injector body over and tap in the palm of the hand to remove the check valve, spring and stop. (Fig. 6-11).

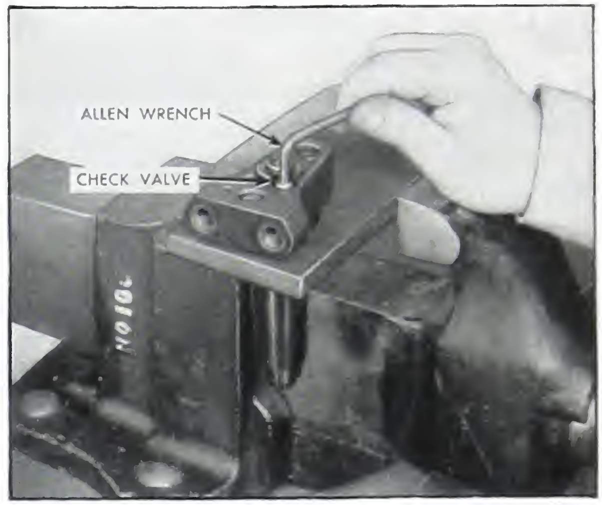


Fig. 6-10. Removing check valve

If any of these parts are stuck in the body; remove the injector cup, insert the plunger in the body and blow the part out with a compressed air jet inserted in the cup end of the body.

Fig. 6-11. Removing injector valve, spring and stop

15. Place the injector in the holding fixture and use the splined wrench, No. 5437, to remove the injector cup, as shown in Fig. 6-12.

16. The check valve seat gasket must be replaced with a new one each time the check valve is removed. Sometimes this gasket remains tightly swaged in the hole. ST-231 is a simple tool to remove the old gasket. Insert the tool and cut the gasket from the body as shown in Fig. 6-13. If the gasket turns and can not be cut, swage it tightly in place with a round nose punch made from an old Model A injector plunger.

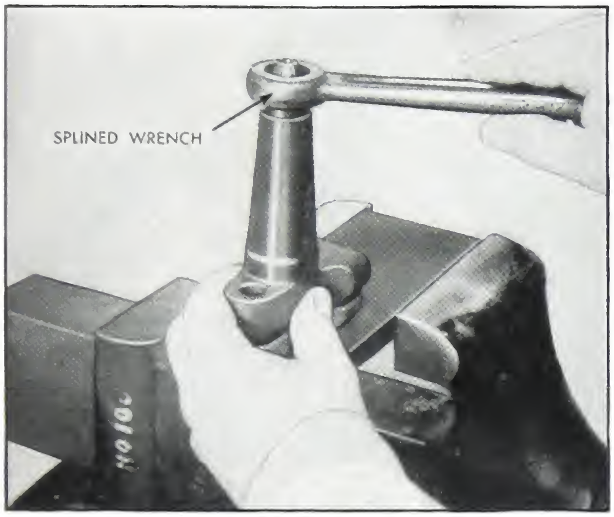


Fig. 6-12. Removing injector cup from body

17. Clean the injector parts thoroughly of any varnish or carbon by immersion in a tank of solvent. Several good solvents are available for this purpose. After carbon in plunger hole of the body is softened by the solvent, it can be easily removed by a small wire brush or steel wool and a wooden plunger. Thoroughly clean the fuel passages in the body by washing in clean mineral spirits or fuel oil. Dry with clean compressed air.

Fig. 6-13. Cutting out injector check valve seat gasket

INJECTOR CUP SPRAY HOLES: 1. The accompanying illustrations show what to look for when inspecting the injector cup. A magnifying glass is necessary to give the cup the inspection it should have, and to determine whether or not any of the following faulty conditions exist.

2. Fine abrasives in fuel, such as dust, dirt, etc., have a sand blasting effect and usually cause the type of failure illustrated in Fig. 6-15. It is important to note that this type of wear can begin internally and result in a faulty spray pattern even though the cup spray holes show no signs of wear from the exterior. Both the interior and exterior of the cup should be closely inspected under a magnifying glass for signs of wear. Faulty spray holes can also be caused by the im-

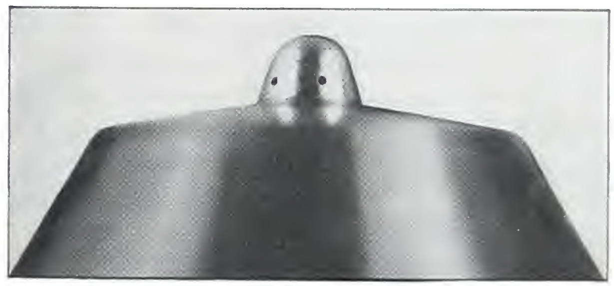


Fig. 6-14. New injector cup tip

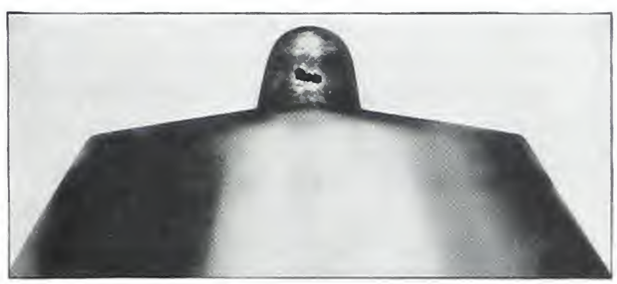


Fig. 6-15. Worn injector cup tip

Fig. 6-16. Corroded injector cup tip

proper use of a cup cleaning drill of the wrong size for the spray hole. Such a condition is frequently caused by breaking the drill off in the spray hole and failing to remove it before putting the injector back in the engine. The extreme pressures that are created in the injector cup have a tendency to start cutting out some place around the drill, wearing the metal away.

3. Fig. 6-16 shows the effect of high acid or sulphur content in the fuel, as well as the effect of excessive heat which could be caused by an overload condition. On the bottom of this cup at "A" the metal has been eaten away.

4. The spray holes of the injector cup must be kept free and open at all times. To continue to operate with the holes obstructed would cause damage to the engine and loss of power.

5. The cup is so designed that the preheated charge of fuel is injected into the cylinder in a fan shaped spray in order to bring the fuel into contact with all available air.

6. Fig. 6-17 shows that in case one injector cup spray hole is plugged with dirt or metal, part of the available air in the cylinder chamber is not in contact with fuel and an over-rich mixture is present in the other part of the cylinder. This causes a falling off in power because of the slow burning of the fuel. The additional burden is then put on the remaining cylinders. To make up for this loss of power in one cylinder, more fuel is fed to the other cylinders than can be burned with the available air. This excess fuel runs down the cylinder walls, causing piston rings to become gummy and to stick. This in turn causes dilution of the lubricating oil in the crankcase.

WARNING: NEVER ALTER THE SIZE OF THE INJECTOR CUP SPRAY HOLES.

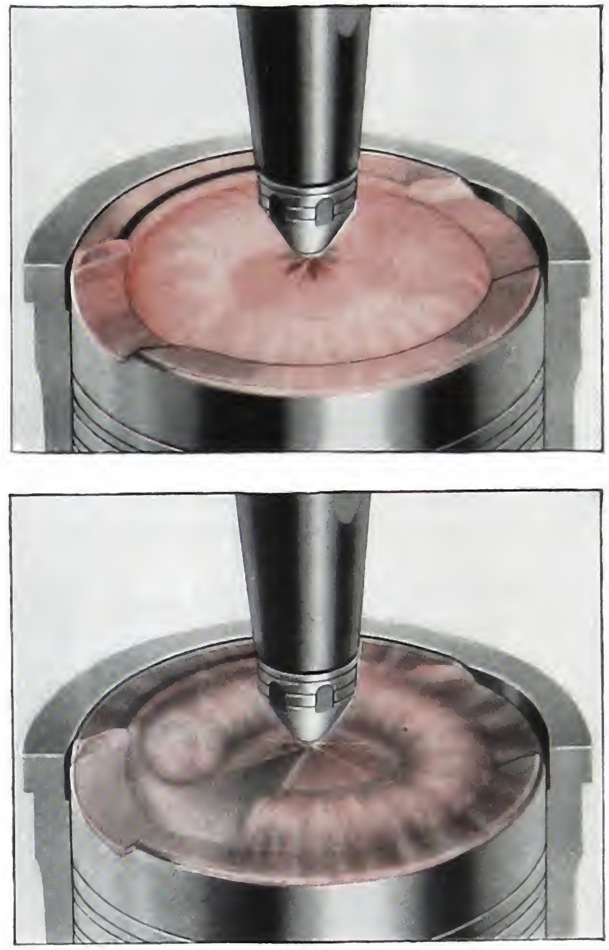


Fig. 6-17. Injector spray diagram

7. Cup cleaning kits are available for each model injector. Each kit consists of a drill vise, several small wire drills, a brush and an angle drill to clean the inside of the cup tip. Spray hole sizes vary with injectors for the different engine models. It is important that the proper kit be used for any particular injector cup. The proper kit number and the diameter of cleaning wire in each kit for injectors used on the different

TABLE—INJECTOR CUPS AND CLEANING KITS

Engine Model	Cup Spray Holes Number	Cup Spray Holes Size	Cup Cleaning Kit Part No.	Cup Cleaning Kit Service Tool No.	Diameter of Cleaning Wire
H, HS, HR, HRS	Six	.0064/.007	S-17	ST-365	.0065
HRBB, NH	Seven	.0064/.007	S-17	ST-365	.0065
NHS	Seven	.0084/.009	S-39	ST-368	.008
NHRS (Cup No. 42928)	Seven	.0094/.010	69152	ST-369	.009
NHRS (Cup No. 44475)	Eight	.0084/.009	S-39	ST-368	.008

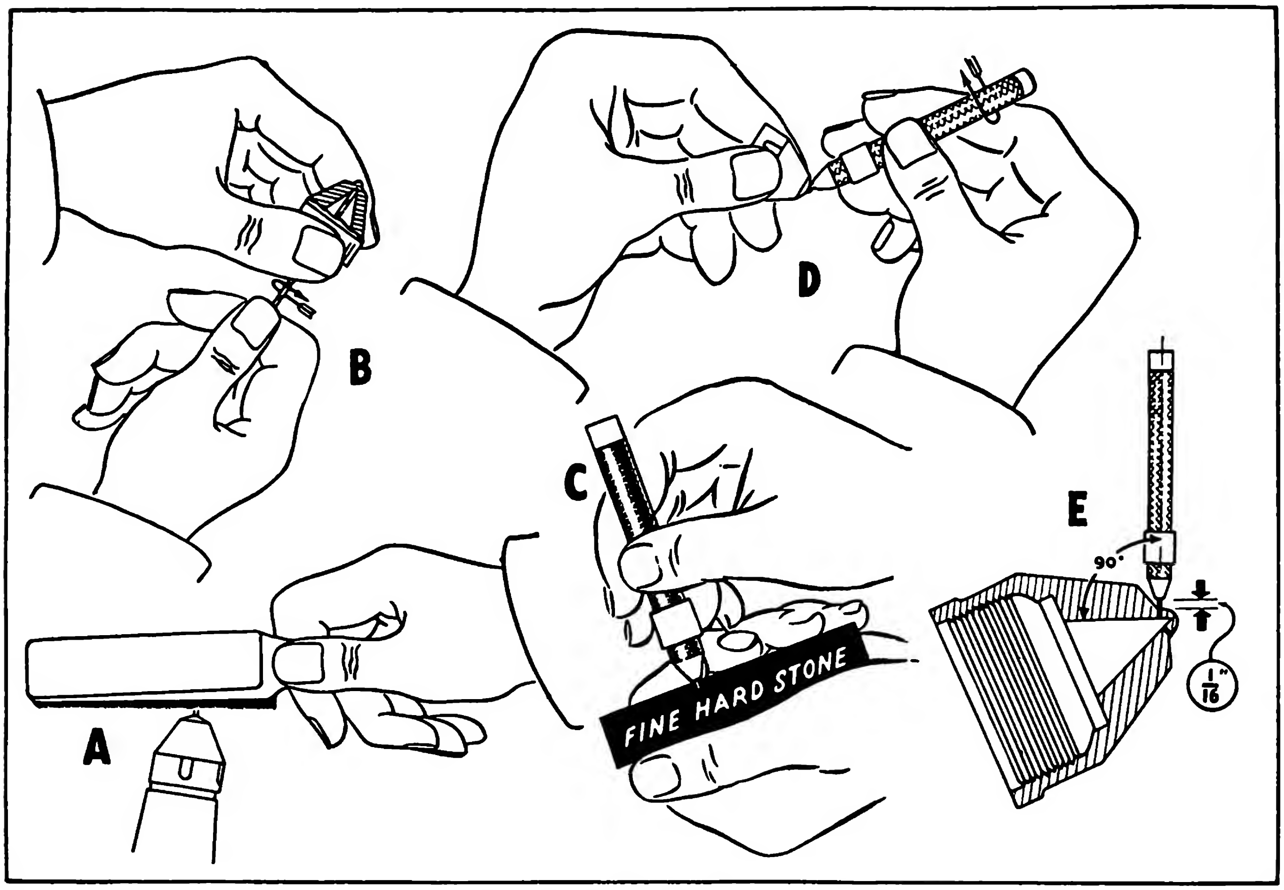


Fig. 6-18. Cleaning injector cup

model engines is shown in the table, "Injector Cups and Cleaning Kits".

8. Before using the small wire drills that are furnished to clean the spray holes, place the wire in the pin vise, letting it project about 1/16" from the end of the vise. With a very fine hone, "C", sharpen the end of the drill to a wedge. This must be done every time a new drill is used or the old one is broken. When a wire drill is cut off or broken, burrs are always present to scratch the inside of the spray holes in the cup. This will cause deflection of the spray and poor combustion. See Fig. 6-18.

9. Hold the cup in the fingers as shown by "D". Be sure to hold the drill to the proper angle as indicated by "E". This will be at right angles to the tip so that the drill will follow the hole as it was originally drilled. When the holes are cleared with the 1/16" extending wire, extend it to ⅛" and ascertain that the holes are completely open.

10. If the holes refuse to open, soak the cup in a solvent (Bendix carburetor cleaner, or equivalent) over night, then use the pin vise as follows: Extend the wire 1/32" from the vise and using a light mallet gently tap the end of the pin vise. Then extend the wire 1/16" and repeat operation until hole is open.

11. Do not use the cup cleaning drill except when the spray holes become clogged. A .001 or .002 variation in the size of the spray holes will cause considerable trouble.

INJECTOR CHECK VALVE: 1. Inspect the check valve and seat under a high powered glass to see that they both have a satisfactory seat. Attempting to reseat this valve is not generally satisfactory although it may sometimes be done by lapping the two together with a very fine grade compound.

2. Check valve and seat are supplied only in pairs and must be installed that way.

CHECK VALVE SPRING: 1. The free length of the check valve spring should be .289. If it is less than 17/64", replace with a new spring.

2. The check valve spring should compress to .193 with a 3.58 ± .35 oz. weight and to .154 with a 5.02 ± .50 oz. weight.

INJECTOR BODY: 1. Inspect the plunger hole of the injector body. If it is scored, the body and plunger should be replaced as an assembly. If scores are not deep, the body may be returned to the factory to be honed and fitted with an oversize plunger.

2. Inspect the cup end of the body. Any dark wavy lines indicate that it has not sealed properly against the injector cup gasket. This end of the body can be refinished as described in following repair instructions.

REPAIR AND ASSEMBLY

Fuel Inlet Connections

1. Assemble the parts of the inlet connection as shown in Fig. 6-2 using new gaskets.

2. Test the ball check valve by blowing through it from the screen end while the valve end is submerged in fuel oil. If any leak is apparent, remove the screw plug and spring and seat the ball by tapping it against its seat with a small hammer and bronze punch.

Injector

REPAIR: 1. If the cup end of the injector body needs refinishing, it can be done with Cutter, Arbor and Pilot, ST-131, as shown in Fig. 6-19. Never remove more than just enough material to clean up the seat.

2. If it was necessary to reface the body with ST-131, it will also be necessary to use Chamfer Cutter, ST-56, to reface the 30° angle on the end of the body to insure proper seal with the injector cup as shown in Fig. 6-20.

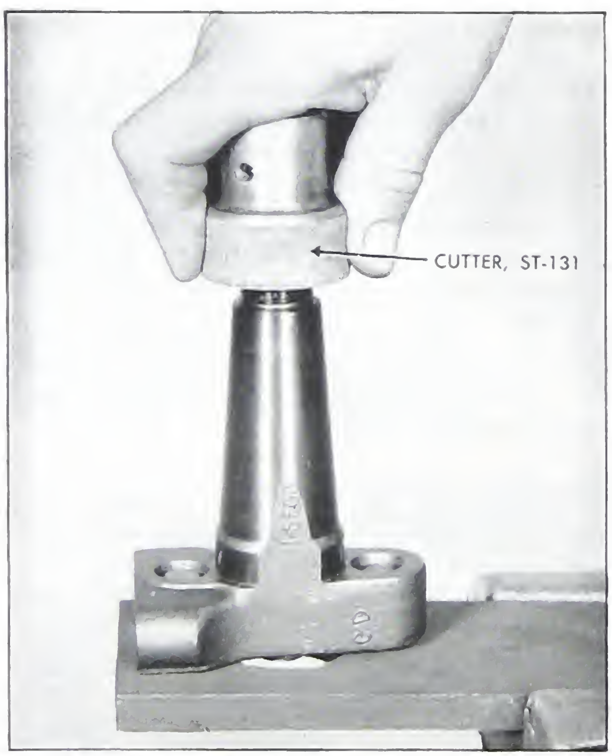


Fig. 6-19. Refacing end of injector body

Fig. 6-20. Cutting chamfer on end of injector body

3. ST-147 is a seating cutter to reface check valve seat and gasket seat in the injector body. These two cutters should never be used except when valve seat has been damaged. If used, they should be adjusted exactly 2⅞″ apart to maintain proper check valve travel after assembly. See Fig. 6-21.

4. Injector body and plunger should be replaced as an assembly, if the plunger shows that it is crooked by uneven wear on one side. The body can generally be salvaged at the factory by honing and fitting an oversize plunger to it. Lapping, reaming or honing of injector bodies should never be attempted in the field. Special factory equipment is necessary for fitting of plunger and body.

5. Flush fuel passages in the injector body with clean fuel oil and blow out with clean compressed air to remove all cuttings from previous operations.

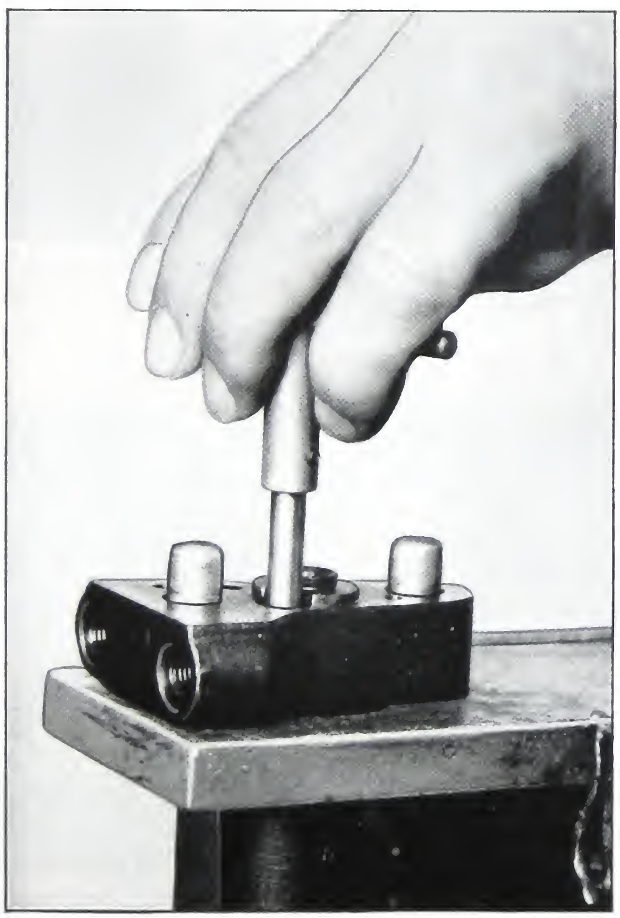


Fig. 6-21. Refacing valve and gasket seats

6. A fuel flow test of the injector body without cup or check valve should give a minimum flow of .7 gpm on H and NH injector bodies and 1.6 gpm on NHS body at 200 psi open pressure. If flow is less than these figures, it indicates that the drilled fuel passage in the body is stifled.

ASSEMBLY: 1. Place the injector right end up in the fixture. Drop the sleeve of ST-216 in the check valve bore of the body and drop check valve stop and spring in place as shown in Fig. 6-22. Test spring action with plunger of ST-216.

2. Install a new copper valve seat gasket, then place the check valve in position coating it with clean cup grease so that it will not fall out while inserting the check valve seat assembly in the injector body. Screw the seat securely in place. See Fig. 6-3.

3. Flush the assembled check valve seat with clean fuel oil to remove cup grease and all particles of dirt or metal. Blow out with clean compressed air.

4. The check valve travel should be checked carefully with gauge, ST-69, to determine the check valve opening. (Fig. 6-24). Limits are .020 ± .005. Too much travel will cause the check valve spring to collapse and too little travel will deprive the cylinder of fuel.

5. If the travel is less than .015, it may be that the check valve seat gasket has compressed too much, and it will be necessary to replace with a new gasket. If there is too much travel, it can be reduced by tightening the seat further to compress the gasket more.

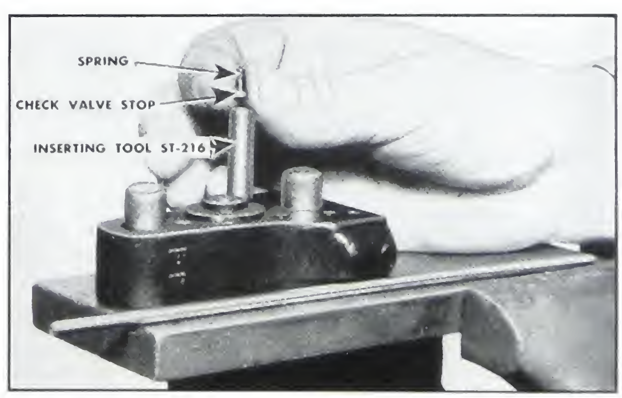


Fig. 6-22. Inserting check valves and spring in injector body

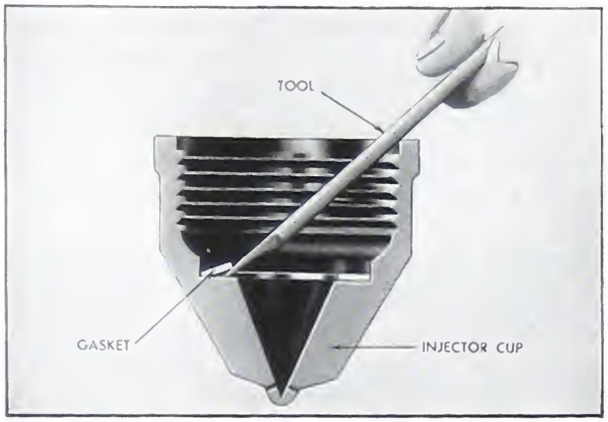


Fig. 6-23. Removing injector cup gasket

6. Always use a new cup gasket when assembling the cup to the injector body. A tool similar to the one shown in Fig. 6-23 will make it possible to remove the old gasket without damage to the body.

CAUTION: USE ONLY GASKETS FURNISHED BY CUMMINS. OLD OR IMPROPER TYPE GASKETS WILL RESULT IN LEAKAGE AROUND THE CUP AND CAUSE DILUTION OF LUBRICATING OIL.

7. The number and size of injector cup spray holes are given in the table "Injector Cups and Cleaning Kits".

8. The injector plunger must seat accurately in the taper of the injector cup, therefore, the following instructions for assembling the injector cup to the injector body should be carefully followed.

9. Place a new gasket in the cup and while holding the injector cup end down, carefully screw the injector cup on the body making sure there is no dirt or burrs to cause a binding condition between the locating section of the injector cup (Fig. 6-23) and the corresponding section of the injector body. The inside diameter of the cup and the outside diameter of the body at this locating section have a machined tolerance of .0002. Mating threads of the cup and body are a free fit to allow the cup and body to make perfect contact in this locating section.

10. Place the injector in the fixture and with spline wrench, No. 5437, tighten the injector cup to 75 foot pounds. This is approximately the same as a 150 pound pull on ST-382 wrench.

Fig. 6-24. Checking injector check valve travel

11. Lubricate the plunger and body with clean, sulfur free, fuel oil and assemble the gasket, plunger, spring and top housing or retaining bail to the injector body as shown in Fig. 6-3 or Fig. 6-4.

INJECTOR PLUNGER LINK: 1. The injector plunger link is lubricated from a drilled hole through the injector rocker lever and socket. The link must be replaced new, if it shows any wear. Loss of lubricating oil at this point—with standard type injectors—will result in the oil draining to the fuel pump where it will be recirculated and burned as fuel.

2. The injector socket in the rocker lever must also be in good condition to prevent lubricating oil loss.

TESTING CONNECTIONS AND INJECTORS

Inlet connections and injectors can be tested as described in following paragraphs on Injector Test Stand, ST-272.

Inlet Connections

1. With inlet connection assembled on stand, and needle valve cracked to allow slow delivery of fuel, the ball check valves of inlet connections should open as follows:

Engine Model	Opening Pressure
A, H, HS, NH, NHS, NHRS	45-55 psi
L, LR	100-110 psi

It is advisable to select inlet connections that open at nearly uniform pressures for any one engine. Fig. 6-25.

2. With 2000 psi fuel pressure against the check valve, it should not leak.

Injectors

1. Rebuilt injectors should always be tested on a test stand. ST-272 is a stand with an air pump that will maintain desired hydraulic pressures and provide for all the tests as directed for the assembled injector.

2. A sleeve for each injector is provided with ST-272 stand to fit over the injector top housing or spring and support the injector plunger in open position. The cups of all injectors fit in a common seat to seal against 2000 psi fuel pressure. Fuel is introduced through the spray holes of the injector cup for leakage and check valve tests.

3. With clean fuel being introduced through cup spray holes, the injector check valve should not leak at 2000 psi. Leaks can be detected at fuel inlet connection hole. Fig. 6-26.

4. Not more than 6 cc fuel per minute should leak by plunger and out drain hole of injector body. If leakage is in excess of 6 cc per minute, the injector should be returned to the factory for honing of body and fitting of new plunger.

5. Assemble an injector and inlet connection to the fuel connection provided for spray pattern test. The spray at 2000 psi should be uniform in pattern and volume. Fig. 6-27.

6. With the lever or hand screw provided, depress the plunger to shut off fuel. With plunger depressed, there should be no leakage at the spray holes.

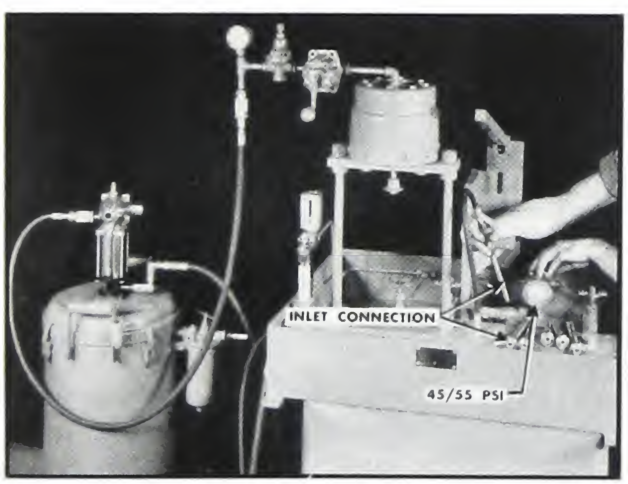


Fig. 6-25. Checking inlet connection check valve opening

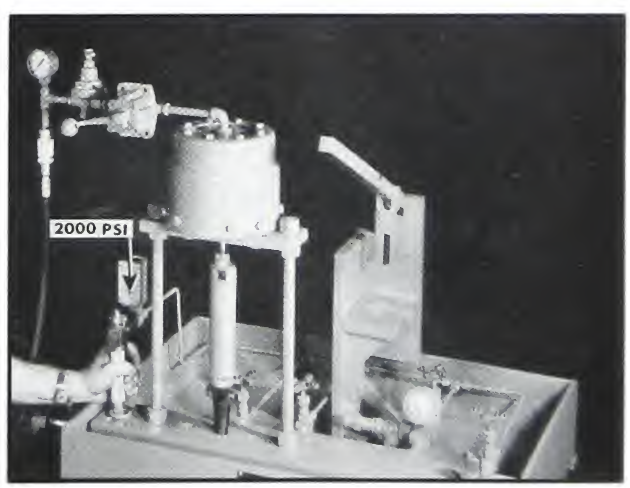


Fig. 6-26. Checking injector back pressure

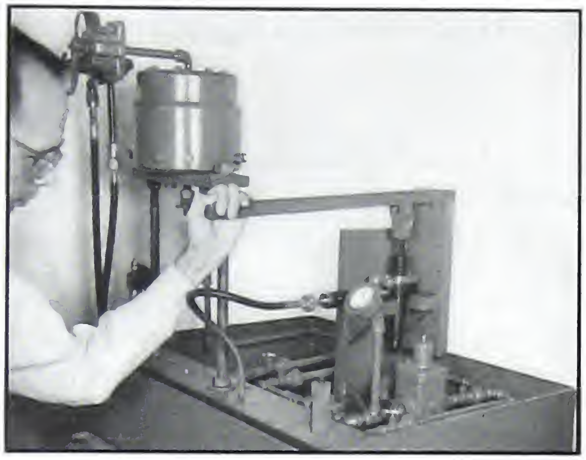


Fig. 6-27. Checking spray pattern

7. Close the high pressure valve and crack the low pressure valve (with 150 psi by-pass) and check the opening of injector check valve and inlet connection check valve in combination. This check valve opening pressure should be about 65 psi.

8. Inlet connections and injectors should be matched in sets with same check valve breaking points and same plunger-body leakage for best performance.

CAUTION: ALWAYS PROVIDE CLEAN FILTERED FUEL FOR INJECTOR TESTS.

SECTION VII

UNIT No. 7

Lubricating System

The working parts of Cummins engines are lubricated by force feed. The force is supplied by a gear-type lubricating oil pump on the fuel pump side of the engine. Oil is held in the sump in the oil pan, and is drawn from this sump, through a screen, by a lubricating oil pump. If a bag-type lubricating oil strainer is used, oil flows from pan-to-pump-to-cooler-to-strainer-to-oil header. If the strainer used has the screen element oil flows from pan-to-pump-to-strainer-to-cooler-to-oil header. The oil header in the block has several outlets which deliver oil simultaneously to all moving parts within the engine. The oil pipes carry lubricating oil from the camshaft to the upper rocker housings, and various drillings through the block, crankshaft, connecting rods and rocker levers complete the oil circulating passages. See Figs. 7-1 and 7-2.

The lubricating oil pressure is controlled by a regulator in the lubricating oil pump. On older model engines the oil pressure regulator is at the gear cover end of the camshaft. The operating pressure at governed speed is maintained at 30 to 50 psi. Filters and screens are provided throughout the system to clean the oil.

Some engines are equipped with oil coolers to maintain closer temperature regulation. Special oil pans and filters, and in some cases a special pump, are provided for certain types of installations.

Oil pans, filters, tubing, coolers, gauges and pumps are the parts or units treated in this section.

DISASSEMBLY AND CLEANING

Oil Pans

1. Remove and discard the strainer bags from pans that have full flow strainers. Save the spool and screen for a new filter bag.

2. Remove the float, if used, and screen.

3. Steam clean the pan, then clean cast iron or steel pans in the hot solvent tank.

CAUTION: MANY SOLVENT CLEANERS ARE INJURIOUS TO ALUMINUM OR OTHER NON-FERROUS METALS. MAKE SURE THAT YOUR CLEANER IS SUITABLE BEFORE USING IT ON ALUMINUM PANS, COPPER OR BRASS TUBING OR SOLDERED PARTS.

4. Clean the pan screen.

Filters And Strainers

1. Remove and discard old strainer bags or elements from the filter cases.

2. Steam clean the filter cases, then complete the cleaning in the solvent tank.

Tubing

1. Clean all lubricating oil tubing, inside and outside, in a tank of suitable solvent.

2. Dip the tubing in a hot water tank and dry with compressed air, inside and outside.

3. Flush all flexible hose lubricating oil lines with a good grade soap cleaning compound at not more than 200° F. Do not use steam!

Oil Cooler

OIL SIDE OF COOLER: 1. To prevent hardening and drying of accumulated foreign substances, the core of the oil cooler should be cleaned as soon as possible after removing from service.

2. On tubular-type coolers, remove the oil by-pass valve and body from the side of the cooler.

3. Remove the front and rear oil cooler heads and gaskets from the cooler.

4. If a plate-type cooler is used, remove the

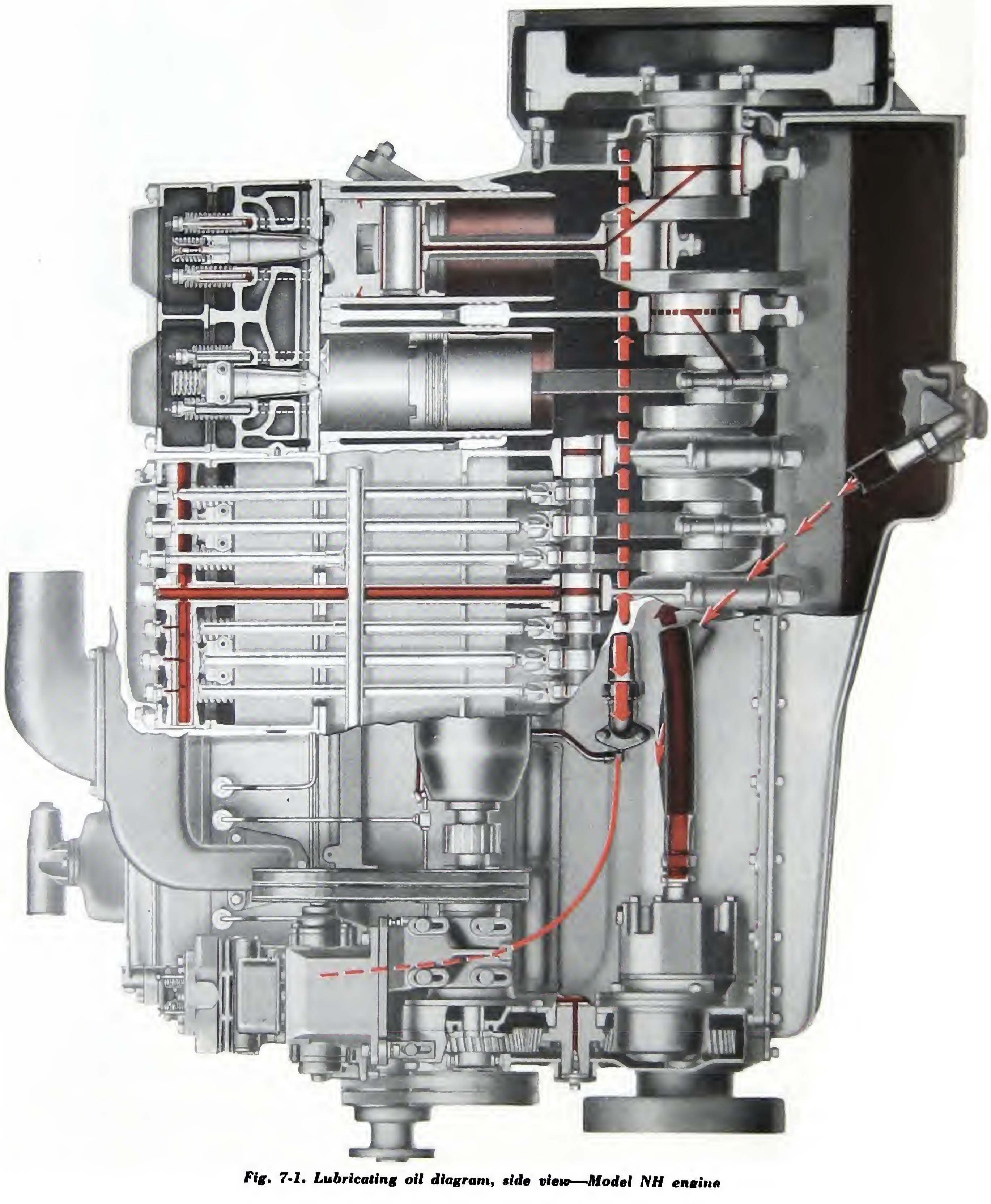


Fig. 7-1. Lubricating oil diagram, side view—Model NH engine

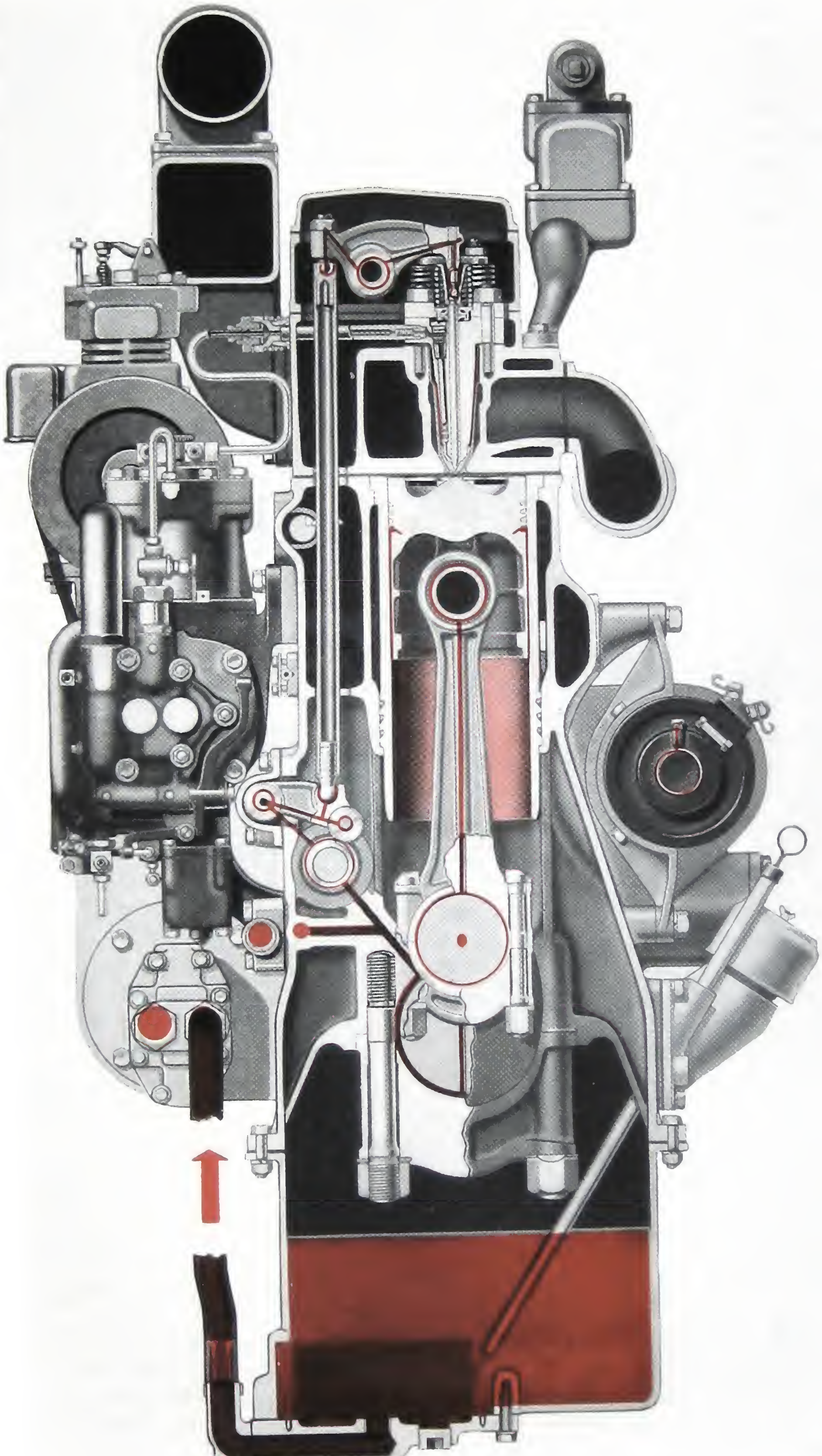


Fig. 7-2. Lubricating oil diagram, end view—Model NH engine

oil cooler cover and take out the core. Loosen the large hex nut from the cover and pull out the spring and plunger of the by-pass valve.

5. On either type cooler, immerse the core in a container of carbon tetrachloride or trichloroethylene or some other approved cleaning solvent. After the unit has been allowed to stand in solvent for several minutes, force the cleaner through the tubes with an ordinary hand rubber suction cup or with a hand or motor driven pump in the reverse direction from the operating flow. Continue the action until the unit is clean. The oil side of the cooler should always be cleaned before the water side.

CAUTION: THIS OPERATION SHOULD BE DONE IN THE OPEN AIR OR IN A WELL VENTILATED ROOM TO AVOID TOXIC EFFECT OF CHEMICALS BEING USED.

6. An oakite or alkaline solution is recommended, particularly where the oil passages are badly clogged. This should be circulated through the tubes. After cleaning, flush thoroughly with hot water.

NOTE: Flush the inside of the oil tubes with clean, light oil after both the oil and water sides of the cooler have been cleaned.

WATER SIDE OF OIL COOLER: 1. Immerse the exposed core of the oil cooler in solution of one part muriatic acid and nine parts water, to which has been added one pound of oxalic acid and .01 gallon of pyridine to each 5 gallons of acid.

2. Remove the core when foaming and bubbling stops. This usually takes from 30 to 60 seconds.

3. Immerse the unit in a 5% solution of sodium carbonate. Remove when bubbling ceases and pressure flush with clean warm water.

4. Clean the inside of the case thoroughly with steam, or solvent, or both.

Lubricating Oil Pumps

STANDARD-TYPE: Two Pump Gears: 1. Remove the eight capscrews and lockwashers that hold the pump body to the pump bracket.

2. Press the idler gear stud from the pump body.

3. Disassemble the by-pass valve, if the body is equipped with a built-in by-pass valve.

4. Place the pump, gear end down, on an arbor press and press the shaft from the ball bearing cage.

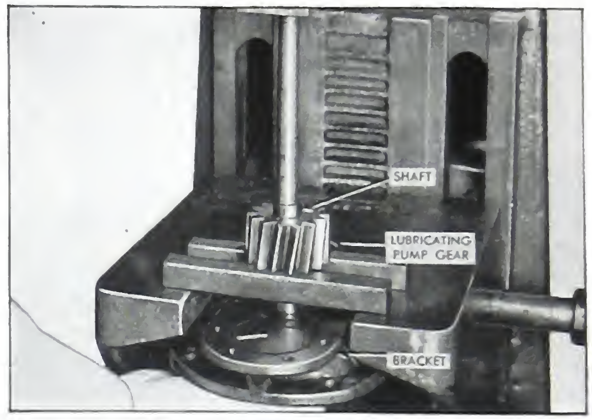


Fig. 7-3. Pressing lubricating oil pump gear from shaft

5. Lift the ball bearing cage from the bracket.

6. Put the bracket and gear in an arbor press, gear end up, with the gear resting on parallels and press the shaft from the gear. (Fig. 7-3).

7. Remove the drive gear key.

8. Remove the cotter key and the hex nut from the end of the drive shaft. Lift the retaining washer from the shaft.

9. Remove the snap ring from the bearing cage and drive the bearing from the cage.

10. Put the disassembled pump in a basket and immerse in the solvent tank to clean. Flush with hot water and dip in mineral spirits or light oil to protect from rust.

SCAVENGING-TYPE: Three Pump Gears: 1. Remove the capscrews that hold the lubricating pump cover to the pump body.

2. Use a bronze punch and hammer to knock the cover from the dowels and body.

3. Use a puller with ¼"-28 capscrews to pull the impeller driven gear from the drive shaft.

4. Remove the Woodruff key from the shaft with a pair of diagonal cutters, or a punch.

5. Pull the impeller idler gear from the idler shaft.

6. Remove the capscrews that hold the pump body to the pump bracket and pull the body from the bracket.

7. Remove the two impeller idler gears from the idler studs and the impeller driven gear from the drive shaft.

8. Complete disassembly of ball bearing cage, ball bearing, drive gear, shaft and bracket in same manner as for standard lubricating pump.

9. Clean parts in cleaning solvent. Rinse in mineral spirits or light oil.

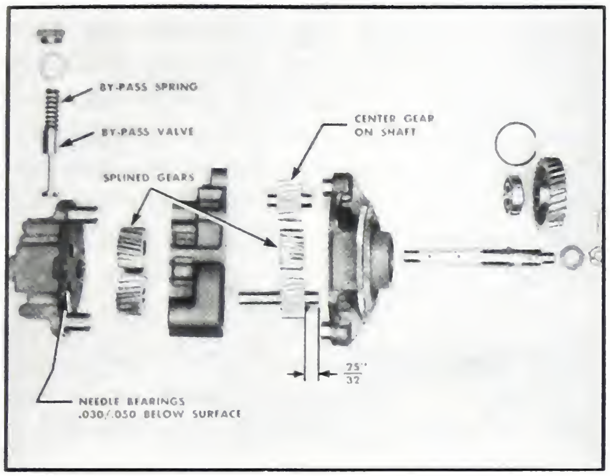


Fig. 7-4. Triple lube pump-five gears

TRIPLE LUBE PUMP: Five Gears: 1. Remove the by-pass valve retainer and washer.

2. Lift out the by-pass valve spring and valve. Fig. 7-4.

3. Remove the by-pass valve housing capscrews and use a bronze punch to knock the housing from the lube pump gear housing.

4. Slide the pressure pump gears from their shafts.

5. Remove the gear housing to pump bracket capscrews and separate the housing and bracket.

6. Lift the idler gears and their shafts from the bracket.

7. Slide the impeller gear from the splined main shaft.

8. Lock the pump drive gear and remove the cotter key, nut and washer.

9. Pull the drive gear, then remove the bearing snap ring.

10. Press out the bearing and main shaft.

INSPECTION

Oil Pan

1. Check the oil pan for cracks. Depending on location of such cracks, they may be repaired by brazing or welding on pressed steel or cast iron pans.

2. Inspect screens in oil pan. If screens are damaged, mark for replacement.

3. On aluminum oil pans, checks the helicoil inserts. If lost or damaged, they should be marked for replacement.

Filter Cases

1. All lubricating oil filters, bag or element-type have a by-pass valve. This valve is absolutely essential to safe engine operation.

2. The by-pass valve of the bag-type strainer is located in the spool. Check to see that the spool has been drilled above the top of the fully compressed spring to permit flow of by-passed oil. Without this drilling, and in case the bag becomes clogged with dirt, the spring will act as a solid sleeve and the bearings will get no oil.

The bag-type strainer is a full flow strainer as long as bags are not clogged.

3. The screen-type strainer also has a by-pass valve which opens if the case or element becomes clogged. Strainers are entirely useless unless they are cleaned often enough to prevent clogging.

4. Bleeder-type filters have by-pass valves and/or orifices. These must be thoroughly cleaned and checked for free action or flow. Since this type filter is fed by a bleeder-line and the flow through this line is determined by its own resistance, the by-pass valve is unnecessary and can be removed. See "Luberfiner Filter", pages 7-9 and 7-10.

Tubing

1. Inspect the tubing for cracks, particularly near flares, and reject if defective.

2. Do not permit any tubing to be reused if it is dented to such an extent that the dent will materially affect the cross sectional area.

3. Mark for replacement any damaged fitting or rubber packing. Make sure the rubber packing is standard for the fitting being used and that it will seal when assembled with fittings.

4. Inspect all flexible hose lines for defects and deterioration. Reject any hose that has become hard and brittle and can not be subjected to bending without cracking. Check for raised or swollen spots, and since flexible hose usually begins to deteriorate on the inside, the suction line from the pan to the oil pump should be thoroughly checked for signs of internal collapse. If this hose should collapse, the entire lubricating oil supply would be cut off. Mark for replacement any defective hose connection or fitting.

Oil Cooler Or Heat Exchanger

TESTING FOR LEAKS IN THE TUBULAR-TYPE OIL COOLER OR HEAT EXCHANGER: 1. Assemble the oil by-pass valve and body to the cooler, and plug the two small pipe-tap holes on the name plate side of the cooler. Plug the oil outlet and attach an air line to the oil inlet.

2. Immerse the unit in water and apply air pressure. The slightest leak will be readily observed by the appearance of air bubbles.

3. Remove the oil by-pass valve and body and assemble the front and rear water heads to the cooler.

4. Plug either the inlet or outlet connection and check for leaks in the same manner as described in Steps 1 and 2.

TESTING FOR LEAKS IN THE PLATE-TYPE CORE: 1. With this type of cooler, remove the core from the casting before testing.

2. Test the core by attaching an air hose to either the inlet or outlet, plugging the other opening, and submerging the assembly in water. Air bubbles will indicate the point where a leak has occurred.

3. Because this plate-type core construction is hydrogen brazed, repairing is not normally recommended. However, in an emergency when spare cores are not available, repairs can be made with a good grade of lead and tin solder. The proper test pressure is clearly shown on the name plate.

TESTING FOR CASING AND GASKET LEAKS: 1. The best test for gasket and casing leaks is the following hydrostatic test. This test will also disclose any tube or header leaks not discovered in the air tests.

2. Pump the core full of oil, or water, depending upon the cooler's intended purpose, to a specified pressure.

3. Fill the coolant side with water and subject it to a higher pressure than that of the core.

4. Permit the unit to stand for a definite period. At the end of this time, check the gauges for any pressure change. If there is a core leak, the casing pressure gauge reading will drop and the core pressure rise. If the casing leaks, only the casing pressure will drop and the core pressure will remain constant.

AIR TEST: Gasket sealed connections are designed to withstand liquid pressures. A high pressure air test for casing and gasket leaks will often permanently fracture a gasket and cause excessive leaking that could have been stopped by tightening the nuts on the gasket cover. In extreme cases, where an air test is employed, use a low pressure.

Gauges

Oil pressure gauges are important instruments to inform us of any unusual conditions in the engine lubricating system. Replace any defective gauge.

Lubricating Oil Pumps

1. The ball bearing outer race must not turn in the ball bearing cage.

2. Drive gear and impeller driven and idler gears must not show excessive wear, or be scored, or otherwise damaged.

3. The drive shaft must be replaced with a new one if (a) it has been turning in the inner race of the ball bearing, (b) it is worn smaller than .8735 where it bears against the bracket bushing, or (c) if it is worn smaller than .8705 on the body end.

4. The bracket bushing should not be used if worn larger inside diameter than .877.

5. Idler pins should be replaced new if worn smaller than .873.

6. Replace bracket or cover with a new bracket or cover and bushing assembly if finished surfaces are scored or visibly worn larger inside diameter than 2.301. Maximum gear to pocket clearance should never exceed .008, or .004 on a side.

7. The by-pass valve in the body should not open below 75 psi.

TRIPLE LUBE PUMP: Five Gears: 1. Check the needle bearings in the housing for wear and corrosion. Needle bearings should be smooth and free turning. If the shaft is scored or brinelled and must be replaced, it is a good indication that the needle bearings must also be replaced.

2. When replacing needle bearings, always press against the numbered side of the bearing. Use an arbor of the same size as the high-limit diameter of the shaft the bearing supports.

3. Check and replace the drive shaft ball bearing if the old bearing is worn, cracked, flaked or brinelled.

4. Replace bodies and covers if the finished surfaces which make contact with gears are scored or worn.

5. The impeller drive and idler gears must not show excessive wear or be scored or otherwise damaged. Maximum gear to pocket clearance should never exceed .016 (.008 on a side.) Gauge with feelers.

6. Thoroughly lubricate and clean all parts before assembly.

7. Check the by-pass spring at the following dimensions: 3½ inch free length; Load at 2⅛"—62/56#.

REBUILDING AND ASSEMBLY

Oil Pans

1. Aluminum oil pans have helicoil inserts in tapped holes. If inserts have been damaged or removed, they must be replaced. Service tool kits—consisting of special taps, removing and inserting tools—are available for these operations. Stripped threads of cast iron pans can also be repaired with helicoil inserts.

2. It is advisable to use a starting and a finishing tap for helicoil inserts for new or oversize holes in aluminum. When tapping aluminum, use kerosene to prevent tearing of metal.

3. After inserting the helicoil, bend the starting end *once* toward the center and then back toward the side of the hole. It will break off clean.

4. Repair any small cracks in cast iron or pressed steel pans by arc welding rather than by brazing. Welding of finished surfaces should never be attempted.

5. If pan is equipped with a float, make sure the float is locked in place with bottom of float within ¾" of bottom of oil pan.

Tubing

1. Replace cracked, dented or broken oil tubes with new tubes.

2. Use new rubber packing to replace old, hardened packing rings. Make sure the rubber packing is the right packing for the fitting and tube. Some packing rings are too short for certain fittings and will not seal even when the nut is drawn all the way to the stop. Replace all defective or cracked flexible hose lines.

Oil Cooler Or Heat Exchanger

TUBULAR TYPE: 1. If a leak occurs in the tube itself, it can not readily be repaired. However, it is satisfactory to insert a smaller ¼" O.D. copper tube inside the damaged tube.

2. Cut and flare the ends of the smaller tube and solder both ends securely.

3. Be careful not to damage adjacent tubes with the torch flame.

4. It is advisable not to restrict more than 5% of the total former capacity of the tubes in this manner. To do so would result in an undesirable increase in operating temperature, as well as considerable pressure drop.

5. A 20% increase in pressure drop demands immediate investigation and probably replacement of the core with a spare.

PLATE-TYPE: 1. Because of their brazed construction, plate type cores rarely develop leaks. Repairs to them are not recommended except in cases of extreme emergency.

2. If repairs are made, replace the repaired cores at the earliest convenience. Should a leak develop along the plate tube seam, it can easily be repaired with a torch, flux, and a solder combination of lead and tin.

HEADER LEAKS: 1. A header leak may occur at the point where the tubes protrude through the header plate or where the header is soldered into the case. Occasionally, through excessive or intermittent pressures, the header plate may become cracked in service.

2. Header leaks can be readily repaired by soldering. Before repairing, clean the damaged spot thoroughly with flux by heating.

3. Care should be taken not to burn the tube or header material with too hot a torch flame.

WIRE-WOUND DOUBLE-WALL TUBE: 1. Water dripping from the tell-tale drain holes indicates leaking in a double-walled tube. If the

headers are disassembled, the faulty tubes can be quickly recognized. It is impractical to repair tubes of this type. However, they can be effectively blocked off by inserting and soldering special plugs into each end of a leaking tube. These plugs can be obtained from the manufacturer upon request.

2. Approximately 5% of the tubes may be blocked off and still allow the unit to function efficiently.

3. If the operating temperature increases sharply, it is an indication that too many tubes have been blocked off and requires probable replacement of the core with a spare.

ASSEMBLY: 1. To reassemble a heat exchanger, reverse the general sequence of operations and reverse each operation described for disassembly of that heat exchanger.

CAUTION: MAKE SURE THAT OIL COOLER ELEMENT IS ASSEMBLED IN THE CASE SO THE INLET AND OUTLET ARE IN THE SAME RELATIVE POSITIONS AS BEFORE REMOVAL. THIS IS TO PREVENT ANY POSSIBILITY OF LOOSENED FLAKES BEING CARRIED INTO THE OIL STREAM.

2. Replace all gaskets with new ones.

3. Check to see that zinc plugs in heat exchangers are clean and in good condition before installing them in the unit. Replace them with new ones if they do not meet the requirements described in inspection section. Zincs must always be replaced if more than 50% disintegrated after they are thoroughly cleaned. New zincs should be installed during rebuilding.

4. After completing any repair operations, a test, identical to that which was employed to discover the leak should be conducted to determine if the repair was successful. If it was not successful, the repair is repeated and the unit retested. The mounting bracket, covers, gaskets, and miscellaneous parts are then reassembled, and the heat exchanger submitted to a final hydrostatic test as described in inspection section. This will reveal any leaks in either the core or housing.

Oil Gauge

Replace any faulty pressure gauges with new ones.

Lubricating Oil Pumps

BRACKET BUSHING: 1. About the only repair work that is feasible on lubricating oil pumps, other than replacement of worn parts with new ones, is line reaming the bracket bushing, No. 9186-1S.

2. Remove worn bracket bushing and press in a new one.

3. Assemble the bracket to reaming fixture, ST-274, and line ream the bushings to .876/.8767.

STANDARD PUMP ASSEMBLY: 1. Install Woodruff key in drive end of drive shaft and press driving gear on shaft until it is snug against the shoulder.

2. Press ball bearing into bearing cage and lock in place with snap ring.

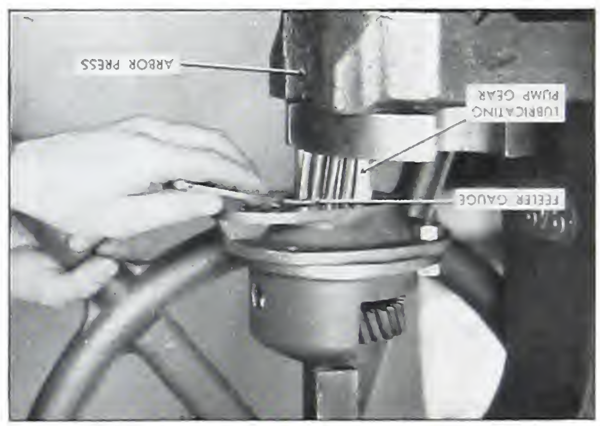


Fig. 7-5. Assembling lubricating oil pump gear

3. Insert end of shaft in cage and install retaining washer, nut and cotter pin on end of shaft.

4. Using new gasket, insert pump bracket over bearing cage. Install Woodruff key in shaft and press pump gear on until shaft gear has a clearance of .0015 between gear and bracket. (Fig. 7-5).

5. Assemble the by-pass valve, spring and spacers, if used, in the pump body. The by-pass valve in the pump body (used in conjunction with increased flow lubricating system) should maintain a pressure of 75 psi in the lubricating oil pump. The spring or combination of spring and spacers should compress to 2⅛" at approximately 45 pounds load.

NOTE: On a right-hand engine the plunger is inserted first and then followed by spring and

retaining plug. For left-hand engines the spring is inserted first and then followed by plunger and retaining plug. Inlet and outlet connections are reversed for right and left-hand engines. Lubricating oil pump bodies are different because of a small drilled oil passage in the pump body which transfers oil to the drive shaft bushing from the pressure or outlet side of the pump body. Consult latest Parts Books.

6. Press idler gear shaft into pump body so that shaft is slightly below face of gear body.

7. Attach pump body to pump bracket with eight capscrews and lockwashers, using new gasket to avoid leakage. Turn drive gear to see that pump gears are free.

NOTE: Gears should always be flush with housing surface when placed in the pockets. Gaskets provide the clearance.

TRIPLE LUBRICATING OIL PUMP: Three Gears: 1. Assemble drive shaft, drive gear, ball bearing, bearing cage and bracket in same manner as for standard pump.

2. Clean gasket surfaces of bracket, body and cover.

3. Assemble the impeller driven gear on the drive shaft. This should be a push fit.

4. With cage held in a vise, lay the impeller idler gears on the bracket, meshed with the impeller driven gear and in position for the idler shafts.

5. Cement two gaskets, 62111, on the body. These two gaskets provide the gear end clearance.

6. If the idler studs have been replaced, press them to place so there is clearance between the ends of the idler studs and the bracket.

7. Lubricate the pump gears. Put the lubricating pump body with assembled idler studs on the drive shaft, fitting the gears over the idler studs. Drive the body over the dowels to place against the gasket and bracket.

8. Assemble the Woodruff key on the drive shaft.

9. Secure the body to the bracket with capscrews and lockwashers. Test for free turning of shaft and gears.

10. Push impeller driven gear on the drive shaft over the key and into the body. This should be a push fit.

11. Put impeller idler gear on idler stud and meshed with impeller driven gear.

12. Cement two gaskets, 62112, to body to provide gear end clearance.

13. Assemble the pump body cover, with dowels, over the end of drive shaft and idler stud and secure with capscrews and lockwashers.

14. Test for free pump action by turning with fingers.

15. It is good practice to run the lubricating oil pump on a test stand to make sure that it does not bind or get hot.

Five Gears: 1. If either the short idler shaft or gear are to be replaced, press the gear on the shaft so it is in the center. Fig. 7.4.

2. If the long idle shaft or drive gear is to be replaced press the gear over the key to 25/32″ from the end of the shaft as shown in the figure above.

3. All new needle bearings should be pressed into position so they are .030/.050 below the housing face.

4. Press a new ball bearing on the pump drive shaft. Press to shoulder.

5. Insert the ball bearing and shaft into the pump bracket and press bearing in place. Secure with the snap ring.

6. Replace the drive gear key, press on the drive gear and secure with a flat washer nut and cotter pin.

7. Slide one of the splined gears over the drive shaft place the short and long idler shafts with their gears in the pump bracket.

8. Place a new gasket over the gear body, dowels and assemble to the bracket. Secure in place with capscrews and lockwashers.

9. Slide the remaining splined gear on the main shaft and the smooth ID gear over the idler shaft. This later gear must float freely on its shaft.

10. Assemble a new gasket to the by-pass valve body.

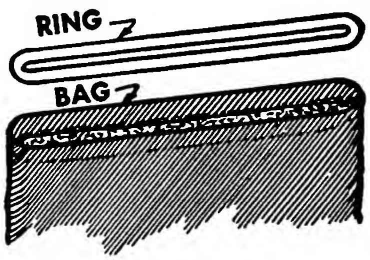
11. Secure the by-pass valve body to the gear housing.

12. Replace the by-pass valve (small end down) spring, gasket and retainer. The by-pass valve should open at 75 psi oil pressure in the lube pump.

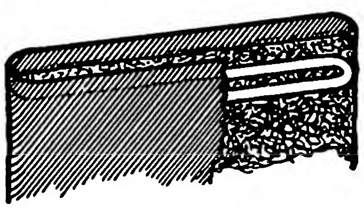
Strainers And Filters

INSTALLING LUBRICATING OIL STRAINER BAG: (Nugent Strainer): 1. To install a new strainer bag, follow closely the steps outlined in Fig. 7-6.

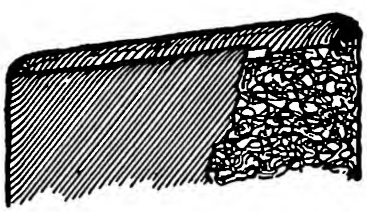
2. Hardened by-pass valve seat inserts can be added to aluminum spools of Nugent strainers to prevent the spring-loaded relief ball from beating out the valve seat and allowing constant by-pass of the lubricating oil. Badly worn or in-



Bag and ring ready for assembling

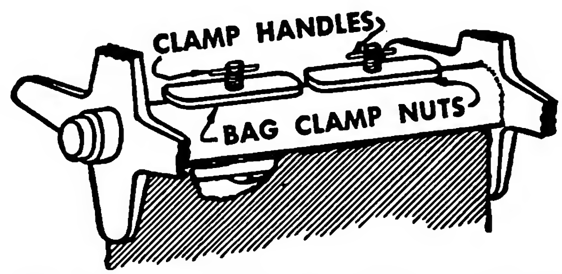


Place ring inside of bag.

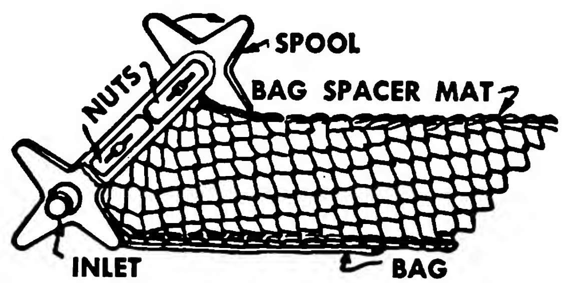


Fold top of bag inward over ring about ½" starting with the ends and then the sides.

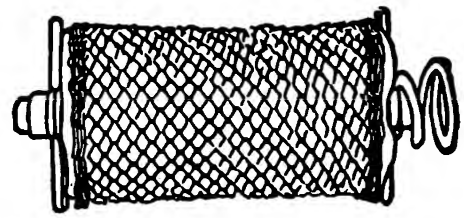
Before applying bag to spool, turn bag-clamps lengthwise so that they will enter bag opening.



Hold bag firmly against spool and give ¼ turn to bag clamp handles which brings them into lengthwise position. Hold handles thus while turning bag clamp nuts to a hand tight lengthwise position.



With inlet end facing you, place spool with bag on a clean flat surface, then lay bag spacer mat on bag making sure they are flat and that the left end of the mat comes up close to the spool. Then roll mat with bag around spool clockwise. The spacer mat must protrude 1½ to 2 inches after the mat and spool are rolled together.



Assembled filtering element ready to insert into shell.

Fig. 7-6. Changing bag of lubricating oil strainer

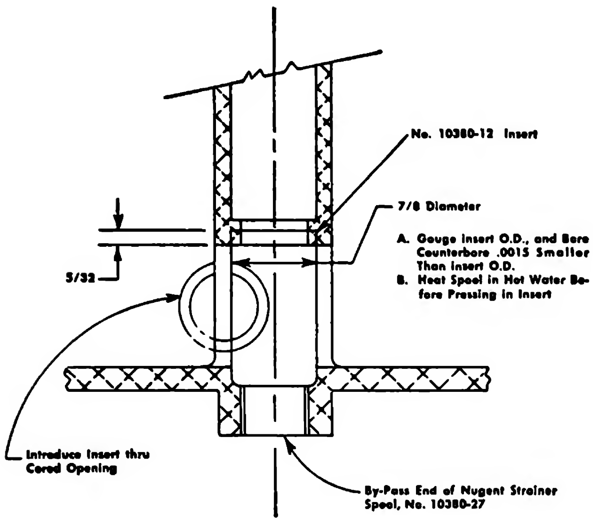


Fig. 7-7. By-pass valve seat insert—Nugent Strainer

effective valve seats should be replaced or repaired. If the valve seat is not too badly worn, the spool can be counterbored and an insert pressed in place as shown in Fig. 7-7.

LUBERFINER FILTER: 1. As described on page 7-5 under "Filter Cases", by-pass valves are unnecessary on bleeder-type filters.

2. To take out this by-pass valve, remove the cover from the filter, and unscrew the by-pass valve assembly. Remove thc large pin that forms the handle, then remove the valve. Drill out the smaller opening with a 11/32″ tap drill. Tap this hole with a 1/8″ American National Pipe Tap. Insert a 1/8″ pipe plug, that has been treated with No. 1 Permetex or similar sealing compound. Replace the large pin.

3. After long usage the spring and seal washer of the Luberfiner Pack hold down assembly may require replacement to insure against oil by-passing the pack. To replace, drive out the handle and lift off the spring and washer. Replace by reversing this procedure using a new seal washer and spring.

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SECTION VIII

UNIT No. 8

Cooling System

Assemblies contained in Unit No. 8 include the water pump, water manifold, thermostats and water piping, water pump and fan drive pulley and belts, fan and hub, sea water pump, bilge pump, belt shield, radiator, heat exchanger, water connections, water system gauge and water vent assembly.

Many of the assemblies in this unit section will require cleaning, inspection and parts replacements only.

DISASSEMBLY AND CLEANING

Water Pumps

CIRCULATING WATER PUMP—For Engines With Fan Mounted On The Water Pump: 1. Using a suitable puller, pull the impeller from the shaft. Fig. 8-1.

2. To remove the seal assembly, remove the small lock ring.

3. Remove the cotter pin, nut and washer and pull the drive pulley with a suitable puller.

4. Remove the lock ring from the pump housing and screw out the retainer.

5. Press the shaft and bearing assembly from the impeller side of the housing.

CIRCULATING WATER PUMP—For Engines With Fan Mounted Over Water Pump: 1. Using a puller in the holes provided, pull the impeller from the shaft.

2. Remove the carbon seal and flexible seal assembly from the body and shaft.

3. Compress the prongs of the lock ring and slide it back on the shaft toward the water pump drive pulley.

4. Press the shaft from the body.

5. Press the shaft from the drive pulley.

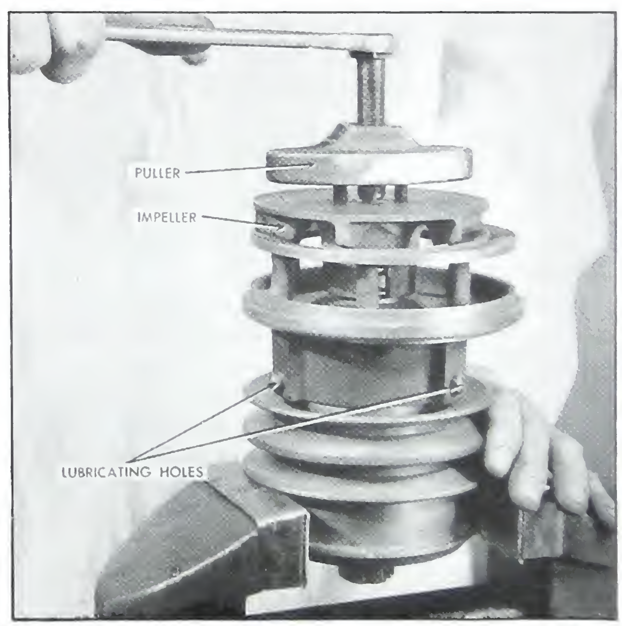

Fig. 8-1. Pulling water pump impeller

Fan Hub

1. Remove the lock nut from the end of the fan pulley spindle and the fan pilot from the fan pulley hub.

2. Remove the fan pulley slotted nut and cotter pin from the spindle.

3. Support the hub on an arbor press, with the small end of the spindle up, and press the spindle out of the hub.

4. Press ball bearings from the hub.

Sea Water Pump

1. Disconnect the inlet and outlet flange and disconnect the oil lines at the top and bottom of the case, then remove the four capscrews holding the pump to the mounting bracket.

2. Remove the nut at the end of the lower pump shaft at the pulley and remove the pulley. The pulley is keyed to the shaft with a No. 8 Woodruff key.

3. Remove the oil drain plug and drain off the oil in the drive gear housing.

4. Clamp the pump body in a vise, being careful not to squeeze the body at the center. Remove the four capscrews from the driving gear housing. The housing can then be slipped off the shafts. Note that there are two dowel pins to insure correct alignment in the assembly.

5. Remove the eight capscrews holding the drive gear housing to the adapter housing. Slip the driving gear housing off the shafts and leaving the adapter housing with the shafts and gears in the vise.

6. Remove the taper pins in the two steel driving gears and remove the steel gears with a gear puller.

7. Remove the snap rings in front of the ball bearings.

8. Remove the two rubber gears from the shafts, using a gear puller and being careful not to damage the shaft ends. Remove all Woodruff keys.

9. Press shafts forward out of the water pump body. Seals and ball bearings will come out with the shafts.

10. Inspect the three oil seals, two in the water pump body and one in the body cover. If these are worn, press the seals from the shafts.

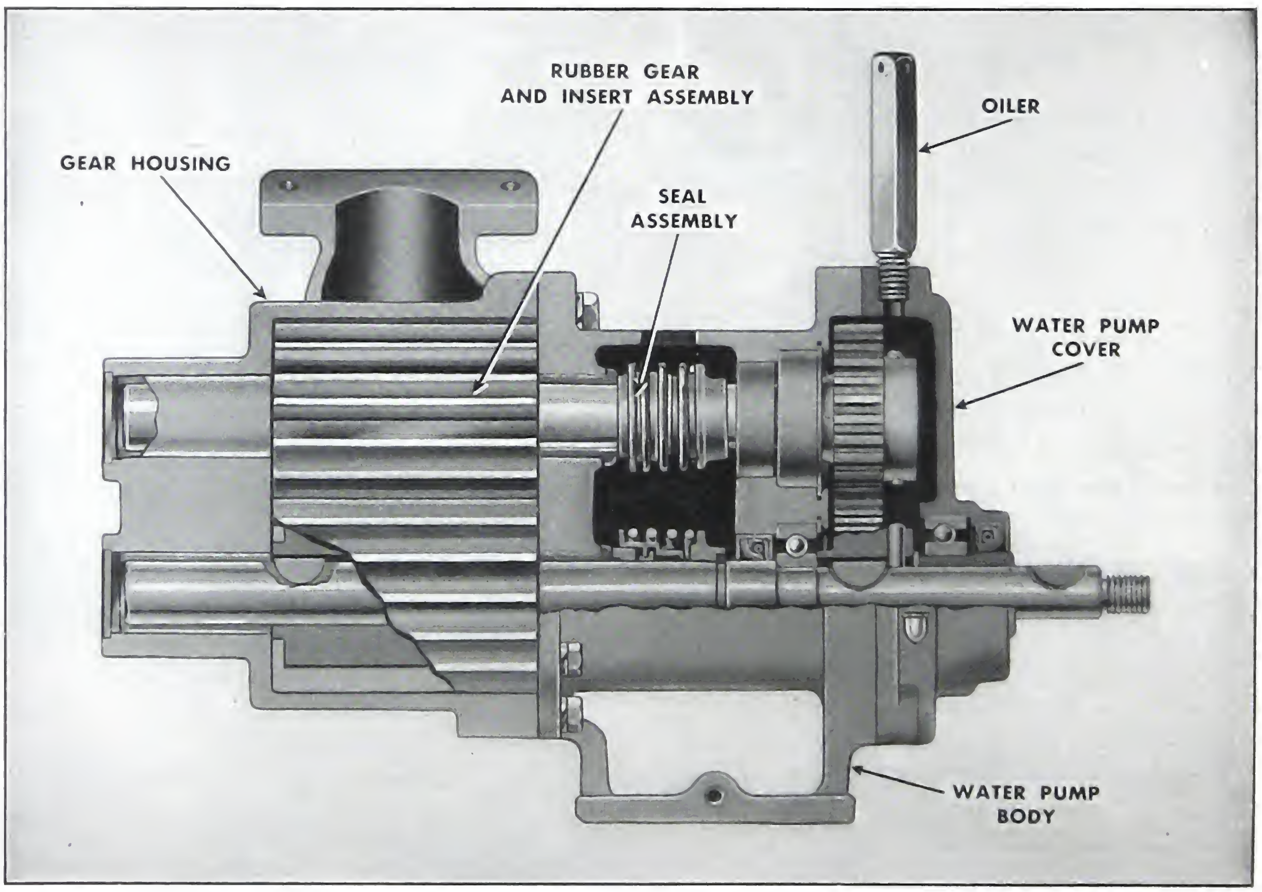

Fig. 8-2. Cross section sea water pump

11. If the bushings in the gear housing are worn, they should be removed.

Radiator

1. To remove core sections with headers, it will be necessary to remove the front screen guard and front screen guard spacers.

2. Remove bolts holding core section header casting to top and bottom tank. Then each core section may be removed from the front of the radiator assembly.

3. If necessary to service any other part of the radiator assembly, the remainder of the assembly may be removed from the unit without danger of damage to the core.

4. The fan screen guard is disassembled by removal of the screws attaching it to the fan shroud.

5. Remove the bolts holding the fan shroud to the side members to disassemble the fan shroud.

6. Overflow tube is removed by the removal of the fitting in the bottom of the top tank and clips holding it to the side member, then pulling it out of the bottom of the top tank.

7. Remove side members from top and bottom tanks completing the disassembly operation.

Heat Exchanger

1. Remove all flanges, hose and connections from the heat exchanger.

2. Remove the cover plates from the oil cooler and water cooler sections of the heat exchanger.

3. Remove both oil and water cooling units, or core from the housing.

Cleaning Of Disassembled Units

1. Clean all non-ferrous parts in special non-corrosive solvent (Bendix carburetor cleaner, or equivalent). Most solvents used for cleaning cast iron are highly corrosive to tin, lead, brass, etc.

2. Immerse all other parts in solvent tank until clean.

INSPECTION

Water Pumps

CIRCULATING WATER PUMPS: 1. Inspect both inner and outer water pump ball bearings. Replace, if rough, or if races are worn.

2. Inspect water pump body clamp ring or heat exchanger bracket and water pump impeller for cracks.

3. Replace water pump impeller if corroded to the extent that it will interfere with circulation.

4. Inspect the seal face of the water pump body. Mark for refacing if it is rough or scored.

5. Replace carbon seal gaskets and cork washers with new parts.

SEA WATER PUMP: 1. Inspect the ball bearings and replace new, if worn or rough.

2. Mark rough or worn water seals for replacement.

3. Inspect the drive and driven shafts and bronze bushings in which they work. If clearance is in excess of .0025, mark bushings and/or shaft for new replacement.

4. Clearance between gear teeth and housing in new pump is .005. If the clearance is in excess of .020 the gears should be replaced.

5. Inspect shaft and bushings for wear. If clearance is in excess of .0025, mark for replacements.

6. Inspect rubber gear assemblies for wear or damage.

Thermostats

1. Replace new any thermostats that are worn to such an extent that action is not positive.

2. Be sure that cleaning has opened vent holes in the thermostat body.

3. Check opening and closing temperatures of

main line and by-pass thermostats. This can be done by immersing the thermostats in water and slowly bringing the water temperature to thermostat operating temperatures. Main line thermostats should open at 160° F. to 165° F. By-pass thermostats should close at 180° F. to 185° F.

4. Operating temperatures given in Step 3 above are for the latest type thermostats. Older thermostats with lower operating temperatures should never be used in an engine.

CAUTION: MAIN LINE THERMOSTATS MUST ALWAYS OPEN AT LOWER TEMPERATURE THAN THE CLOSING TEMPERATURE OF THE BY-PASS THERMOSTATS.

5. Some engines may be equipped with special high range thermostats, opening or closing temperature is stamped on the element.

Fan Hub

1. Inspect ball bearings and fan pulley spindle. Replace with new parts if worn or rough.

2. Replace oil seals, washers and gaskets.

3. Inspect the fan pulley hub and pilot for cracks.

Radiator And Heat Exchanger

Check radiator and heat exchanger cores for leaks. Both lubricating oil cooler and water cooler sections of heat exchanger should be inspected as directed in Unit 7, page 7-5.

REBUILDING

CIRCULATING WATER PUMPS—For Engines With Fan Mounted On Water Pump: 1. The only machine operation that can be performed in the service shop on circulating water pumps is refinishing the seal face of the water pump body.

2. If the seal face of the water pump body is scored or worn unevenly, insert the locating mandrel, ST-253, in the pump body.

3. Use a flat stone in a valve grinder and a .375 valve grinder pilot as shown in Fig. 8-3 to reface the water pump body seal face.

4. Replace worn or damaged ball bearings, carbon seal, flexible seal, spring, impeller, etc., as needed.

5. Factory exchanges of completely rebuilt water pumps are available at a lower price than they can generally be rebuilt in a repair shop.

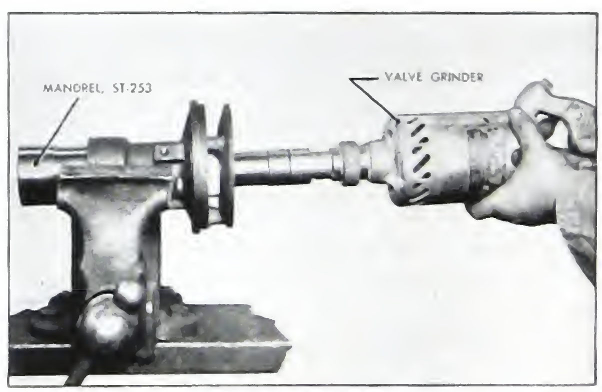

Fig. 8-3. Refacing seal face of water pump body

RADIATOR AND HEAT EXCHANGER: Repair any leaking cores of radiator or heat exchanger in the same manner as described for repair of oil cooler, Unit Section 7, page 7-6.

TIMING MARKS ON WATER PUMP OR FAN DRIVE PULLEYS: 1. Latest specifications provide that fuel delivery to the injectors shall start at the beginning of the compression stroke. This timing is 90° later than that originally used on engines previous to Engine Serial No. 72125. Timing marks on camshaft gears and on water pump drive pulleys have been changed to agree with this latest timing of fuel distribution.

2. Inspect the timing marks on the water pump, or fan, drive pulley and compare to the applicable drawing below. If the markings differ, remove the old marks and relocate as indicated.

3. Refer to "timing marks on cam gears," page 2-8 to make sure cam gear is correctly marked.

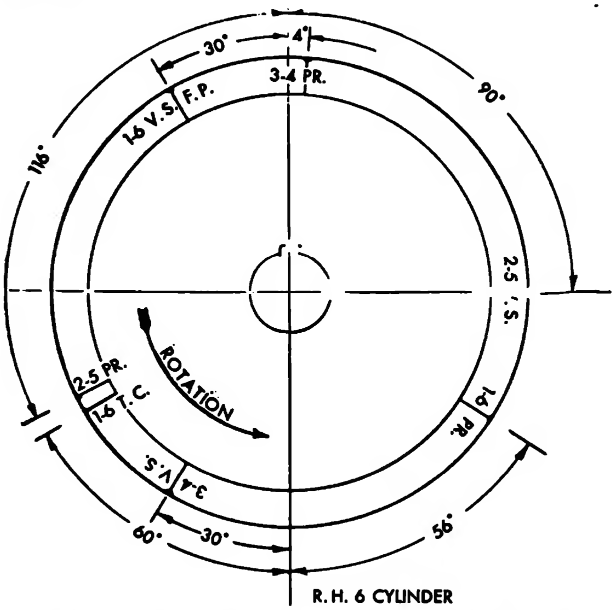

Fig. 8-4. Timing marks on 6 cylinder right hand engine fan drive pulley

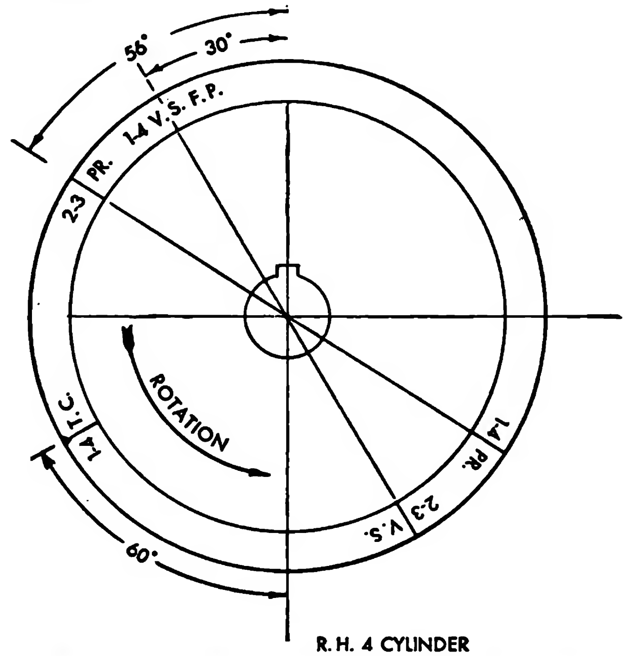

Fig. 8-6. Timing marks on 4 cylinder right hand engine fan drive pulley

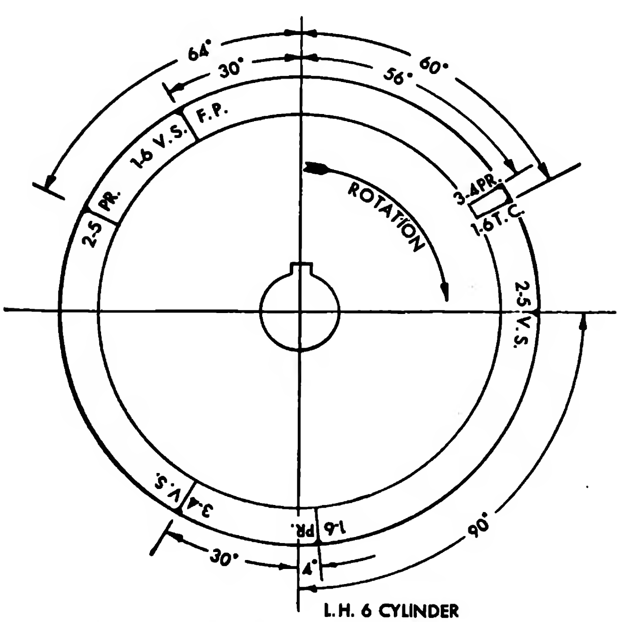

Fig. 8-5. Timing marks on 6 cylinder left hand engine fan drive pulley

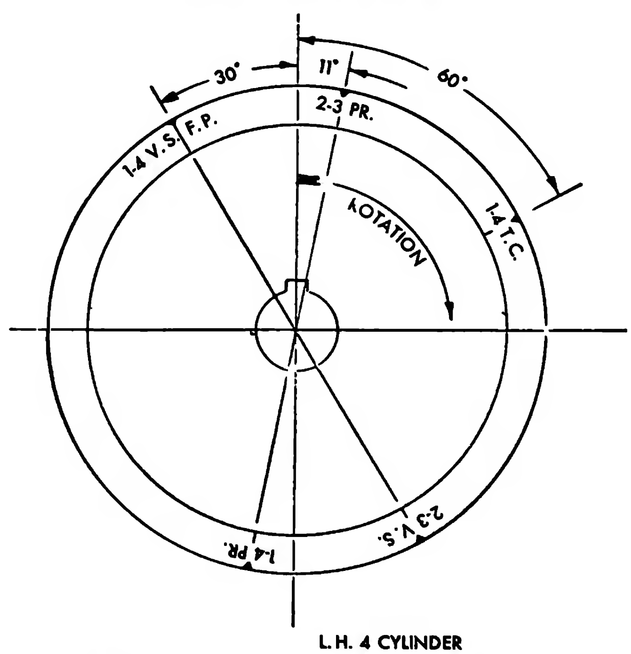

Fig. 8-7. Timing marks on 4 cylinder left hand engine fan drive pulley

ASSEMBLY

Water Pumps

CIRCULATING WATER PUMP—For Engines With Fan Mounted On The Water Pump: 1. Assemble bearings to shaft with spacer, lock ring and retainer. Pack the space between the two bearings with ball bearing grease.

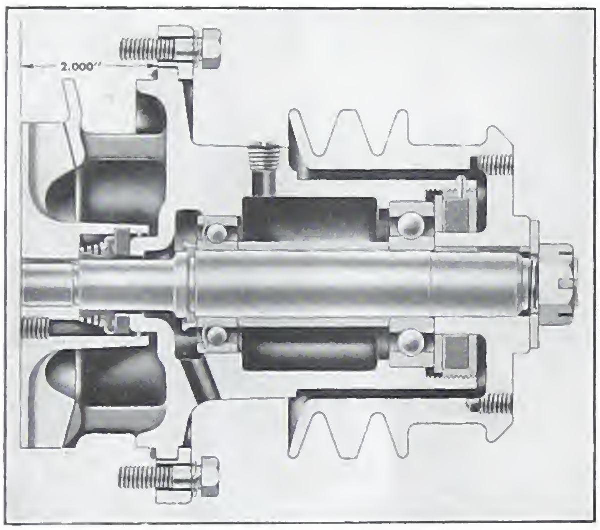

Fig. 8-8. Cross section of water pump

2. Assemble Woodruff keys to shaft, and press the shaft and bearing assembly into the water pump housing.

3. Insert gasket and washers, if used, and

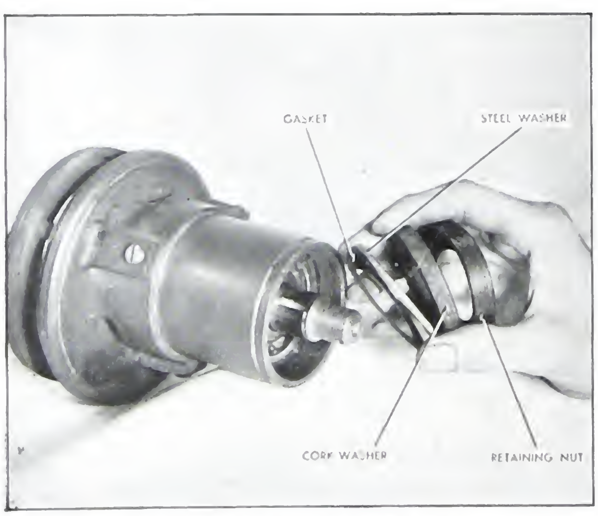

Fig. 8-9. Water pump bearing retainer

screw the retaining nut down tight, lining up lock ring hole and inserting lock ring in place. (Fig. 8-8).

4. Assemble carbon seal assembly to impeller and secure in place with lock ring. (Fig. 8-10).

5. Press impeller in place until it is down

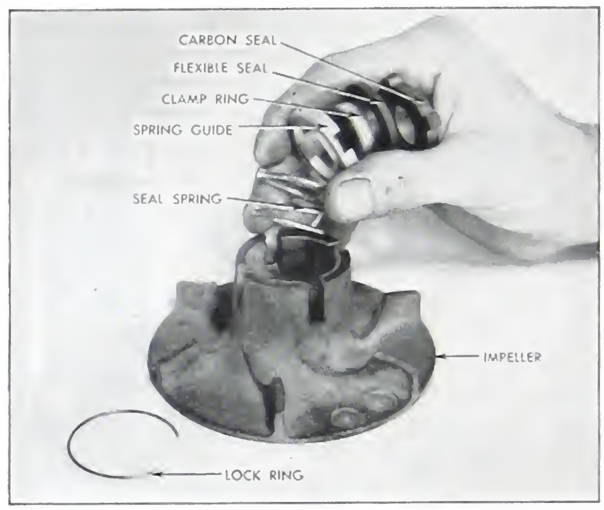

Fig. 8-10. Water pump shaft carbon seal

against shoulder of shaft.

6. Press the driving pulley on the shaft and lock in place with nut and cotter pin.

CIRCULATING WATER PUMP—For Engines With Fan On Fan Hub Mounted Over Water Pump: 1. Replace worn with new parts. Assemble spacer and bearings to the shaft and pack with ball bearing grease.

2. Press the shaft assembly into the body to the stop.

3. Place the lock ring in position to the body.

4. Press the shaft into the drive pulley, while resting the pulley on a small steel disc to prevent breaking the pulley and to serve as a stop for the shaft.

5. If the carbon seal is scratched or broken, replace with a new seal.

6. If the spring or rubber seal is damaged, or if the outer cup does not work freely over the inner cup, replace the seal assembly as a unit.

7. Place the flexible seal and the carbon seal in the seal retainer of the body.

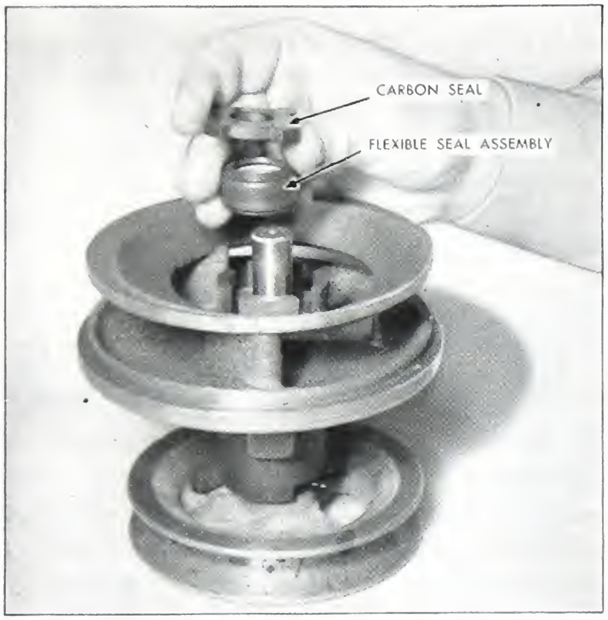

Fig. 8-11. Water pump seal assembly

8. While resting the drive pulley on a small steel disc, press the impeller on the shaft to a distance of 2.000 from the inside surface of the pump body mounting flange to the outer face of the impeller. See Fig. 8-8.

9. Install dirt exclusion plate on all water pumps where fan extension hub is used.

SEA WATER PUMP: 1. Replace the oil seals and bushings if worn. Press bushings evenly into place so that the edges of the bushings are flush with the face of the housing. This will necessitate inserting two new Welch plugs. Check the bushing wear on the shaft for proper fit.

2. Press the shafts, with seals, spring assemblies, and ball bearings, into the pump body.

CAUTION: WHILE INSERTING THE SHAFTS AVOID DAMAGE TO THE OIL SEALS BY FIRST INSERTING A TAPERED PIN, OR DRIFT PIN, OF CORRECT DIAMETER. FOLLOW THROUGH WITH THE SHAFTS. OIL SEALS SHOULD ALWAYS BE INSTALLED WITH THE FEATHER EDGE AGAINST THE OIL.

3. Install the snap rings in the pump body to hold the ball bearings in place.

4. Insert Woodruff keys and, with an arbor press, press the steel gears on the shafts against the inner race of the ball bearings.

5. Drill and ream the shafts, with the gears in place, with a No. 5 taper reamer and pin with new taper pins.

6. Press the rubber gears over the shafts, using a temporary .015 spacer between the end of the gear and the pump body. Be careful to press against the end of the shaft. Remove the spacer after the gears are pressed in position. Test the pump gears for free turning.

7. Place a new gasket against the pump body flange and slip the gear housing over the gears and secure with eight capscrews and lockwashers.

8. Install the ball bearing and oil seal in the water pump body cover. Assemble the cover with gasket to the pump body and secure with four capscrews and lockwashers.

9. Install a new gasket and assemble the flange coupling over the inlet and outlet ports of the gear housing.

10. Assemble drain plugs and/or oil fittings as previously removed.

11. Replace the driving pulley and draw up securely with lockwasher and nut.

12. Replace the pump assembly on the mounting bracket and connect the water inlet and outlet and the oil feed line.

13. Test the pump on the engine and watch for overheating during the first ten minutes of operation.

14. Shaft bushings in the gear housing are designed for water lubrication and should require no further attention. The steel gears and bearings at the front of the pump are lubricated through a self-contained oiling system. This oil sump should be kept filled with SAE 20 or 30 lubricating oil.

Fan Hub

1. Press the outer races of both ball bearings in the fan pulley hub. The inner races are a hand-push fit on the spindle.

2. Assemble the spindle and inner ball bearing races in the fan pulley hub.

3. Assemble the hub clamp and pulley clamp washers and lock nut on the large end of the spindle.

4. Assemble the cone clamp washer and lock nut to the small end of the spindle. Draw up the lock nut tightly, back nut off one castellation and secure with cotter key.

5. Assemble the fan pilot with gasket to the pulley and secure with six capscrews and lock-washers.

6. Fill the housing with ball bearing grease and insert pipe plug. In some cases a relief grease fitting S-1109 is used to allow filling the fan hub with grease.

Radiator

To reassemble radiator, reverse disassembly procedure.

Heat Exchanger

1. Install oil cooler and water cooler units in heat exchanger housing.

2. Replace all old gaskets with new ones. Dip the new gasket in light machine oil for 1 or 2 minutes before installing. Assemble covers and mounting brackets with capscrews and lock-washers.

3. Replace old disintegrated zincs with new zincs.

4. Seal the core outlet and seal the core with oil or water depending upon the type of core. Seal the inlet with the fitting designed for the application of an air hose and gauge. Subject the core to the specified pressure allowing only atmospheric pressure in the casing.

5. Permit the unit to stand for 15 or 20 minutes, then check the pressure gauge for pressure drop which will denote a tube or header leak. To test the case, seal the coolant outlet and seal the casing with water, then follow the same procedure as in the core test. A pressure drop on the gauge will denote a casing leak.

6. If the core is not intended for immediate use after repair and test, it should be prepared for storage. Allow the unit to drain thoroughly and blow out the remaining liquid with air. Dry with warm air, then flush light machine oil or soluble oil through the tubes and drain off excess. Seal all inlets and outlets to prevent the entrance of dirt or foreign matter.

SECTION IX
UNIT NO. 9
Drive Units

The generator drive, generator and compressor drive, supercharger drive, supercharger and accessory drive and fuel pump and compressor drive units are included in this section.

Oil seals and ball bearings are about the only replacements needed in rebuilding of drive units.

BALL BEARINGS: Since ball bearings are so extensively used in drive units it is well to review some of the general rules concerning their use and handling.

1. Ball bearings should be installed or removed from housings with an arbor press and with the right size and type of mandrel or plate. Pressing should be done on the race that is press fit. When the bearing is being pressed into a housing the force should always be applied on the outer ring.
2. Work with clean tools, in clean surroundings.
3. Remove all outside dirt from housing before exposing bearings.
4. Handle with clean dry hands.
5. Treat a used bearings as carefully as a new one.
6. Use clean solvents and flushing oils.
7. Lay bearings out on clean paper.
8. Protect disassembled bearings from dirt and moisture.
9. Use clean, lint-free rags, if bearings are wiped.
10. Keep bearings wrapped in oil proof paper when not in use.
11. Clean inside of housing before replacing bearings.
12. Install new bearings as removed from the package, without washing.
13. Keep bearing lubricants clean when applying and in covered containers when not in use.
14. Pack used and washed bearings with ball bearing grease before installation.
15. Do not take new bearings apart.
16. Never press against bearing separators.
17. Never pound on a bearing or ring.
18. Do not spin bearings before cleaning. Do not spin by force of air. Hold both rings while drying with clean compressed air.
19. The following types of defects are such as to cause bearings to be rejected for further use:
    a. Broken or cracked rings.
    b. Dented shields or seals.
    c. Cracked or broken separators.
    d. Flaked areas on balls, rollers or raceways.
    e. Broken or cracked balls or rollers.
    f. Bearings which have been overheated. These bearings are generally darkened to brownish-blue or blue-black color.
    g. Bearings whose raceways are indented or "brinelled" by impressing balls or rollers into the races.
20. Dirt causes ball bearings to fail.

OIL SEALS: 1. When an oil seal fails to seal it is useless.

2. Oil seals are easily ruined by allowing them to turn while installing shafts against the sealing lip, or by keys in shafts.

3. The sealing lip must always compress *with* the pressure.

BORES IN HOUSINGS: 1. Ball bearings must not turn in the housing retaining bore. If the old bearing has turned and ruined the housing, both bearing and housing must be scrapped.

2. Bore of the housing must be clean before pressing the bearing in place.

DISASSEMBLY AND INSPECTION
Generator Drive

DISASSEMBLY: 1. With light blows, drive the bearing cage from the bracket.

2. Remove cotter pin, nut and retaining washer.

3. Pull the gear from shaft or press it from the shaft using a set of parallels under the gear. (Fig. 9-1).

4. Remove the Woodruff key and press shaft

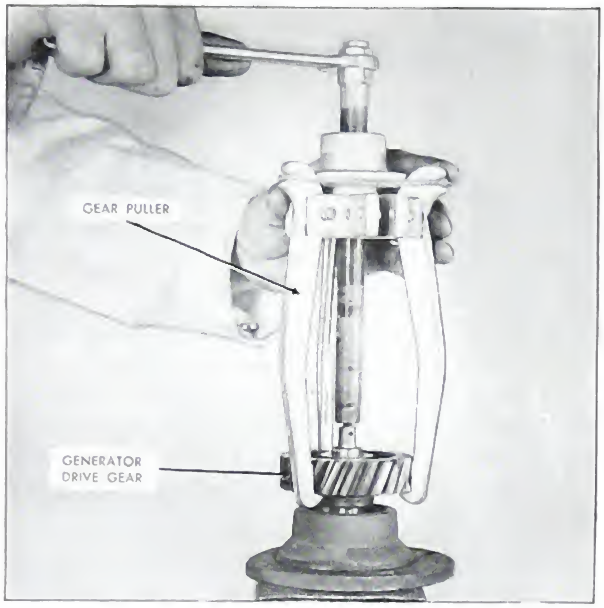

Fig. 9-1. Pulling generator drive gear

from the bearing and cage.

5. Remove the nut and lockwasher and press the shaft from the coupling spider.

6. Remove the lock ring from the bearing bracket and press the bearing from the bracket.

INSPECTION: 1. Inspect the drive gear for broken teeth or excessive wear.

2. Wash ball bearings in mineral spirits. Check for worn or rough races and rough action. Discard if bearing is rough or if there is any perceptible play.

NOTE: No. 9171-1 generator drive gear is used on all Model H generator drives and on Model NH non-supercharged engines between serial numbers 43576 and 43655 inclusive. Consult gear data, page 2-31.

Generator And Compressor Drive

(For Compressor Mounted Over Generator)

DISASSEMBLY: 1. Remove cotter pin, nut and lockwasher from pulley end of drive unit and, using parallels under the pulley, press the sheaved pulley from the shaft. Remove key from shaft.

2. With light blows drive the gear cage from the cage cover. After separating cage and cover, use parallels in an arbor press to press cage off the shaft assembly.

3. Remove exposed key from shaft.

4. Grasp shaft in copper jawed vise. Remove nut and lockwasher. Press coupling spider from shaft. Remove Woodruff key.

5. Remove snap rings and press ball bearings and oil seals from cage.

INSPECTION: 1. Replace oil seals, cage packing and gaskets with new parts.

2. Wash ball bearings in mineral spirits and test for worn races and rough action. Replace defective bearings with new ones.

Supercharger Drive

DISASSEMBLY: 1. Remove the nut and washer from the coupling.

2. With a suitable puller, remove the drive coupling from the shaft.

3. Remove the bearing cover from the shaft.

4. Lift the coupling key from the shaft.

5. Press against the coupling end of the shaft to remove the gear.

INSPECTION: 1. Check ball bearings for worn races or rough action and replace, if needed.

2. Replace oil seal and gasket with new parts.

3. Check gear for uneven wear or broken teeth.

Fuel Pump And Compressor Drive

DISASSEMBLY: 1. The fuel pump drive for engines without compressor mounted over the drive and the fuel pump and compressor drive are alike except for the housing and the use of a spacer instead of a compressor drive pulley.

2. Remove nut and lockwasher from coupling end of shaft and press or slide the coupling from the shaft.

3. Press spacer or pulley from shaft and remove the key from the shaft.

4. Press the shaft and gear assembly out of the housing.

5. Remove oil seal, snap ring and ball bearings from housing.

6. Remove nut and lockwasher and press ball bearing and drive gear from the shaft.

7. Remove keys from shaft.

INSPECTION: 1. Most coupling spiders are made to slide over the hub of the pulley. This permits changing compressor drive belts without

removing the fuel pump from the engine.

2. Inspect ball bearings and replace with new ones, if they are worn or rough.

3. Replace worn oil seals with new ones.

ASSEMBLY

Generator Drive

1. Assemble the Woodruff key to the shaft and press the coupling spider on the shaft to the shoulder. Lock in place with lockwasher and nut.

2. Replace worn oil seals with new ones.

3. Press the ball bearing into the cage and lock in place with the snap ring.

4. Press the coupling spider and shaft into the bearing and cage.

5. Assemble the Woodruff key to the shaft. Using a tube or a large wrench socket, press the gear and bearing into position.

6. Assemble the retaining washer and nut to the shaft. Tighten and lock with cotter pin.

7. With new gaskets, assemble the bearing cage over the bearing all the way to the bearing bracket.

Generator And Compressor Drive

1. Press the oil seal in the cage cover with the sealing lip turned inward.

2. Put snap ring in the lower groove of the cage cover.

3. Pack ball bearings with grease.

4. Press the ball bearing against the snap ring in the cage cover and lock with the top snap ring.

5. Coat gasket surface of cover with Permatex and cement gasket in place.

6. Assemble Woodruff key in short end of shaft.

7. Grease shaft and press coupling spider on short end of shaft with hub to shoulder.

8. While holding shaft in copper jawed vise, assemble the lock plate and nut to secure the coupling spider on the shaft.

9. Press the shaft and spider to place with the hub of the spider in the ball bearings.

10. Assemble Woodruff key on shaft. Grease the shaft and press the drive gear on the shaft with the hub to the cover. Press all the way to the bearing.

11. Press bushing, No. 65257, into ball bearing, S-16002. Press bearing on the shaft with the flange of the bushing to the gear.

12. Press the oil seal in the cage with the sealing lip toward cage.

13. Assemble Woodruff key to shaft.

14. Press the bearing cage on the shaft assembly to cover flange. Use a 7/16" pin to line up holes in gasket, cage and cover. See Fig. 9-2.

15. Cement gasket with Permatex to cage flange.

16. Assemble the sheaved pulley over the key to the shaft with the hub in the oil seal. Lock in place with lockwasher, nut and cotter pin.

Supercharger Drive

1. Press the gear over the key and shaft to the shoulder on the shaft.

2. Assemble the bearing to the shaft.

3. Assemble the key to the shaft.

4. Assemble a new oil seal in the bearing cover and assemble the cover over the shaft and bearing.

5. Press the coupling to the shaft over the key and secure in place with the washer and nut.

NOTE: Supercharger and accessory drive is assembled in the same manner except for additional pulley and a different shaft.

Fuel Pump And Compressor Drive

ASSEMBLY: 1. Put compressor gear key, spider and pulley key on the shaft and press the drive gear over the key on the shaft to the collar.

2. Pack ball bearings with grease.

3. Press the ball bearing on the drive gear end of the shaft to the gear.

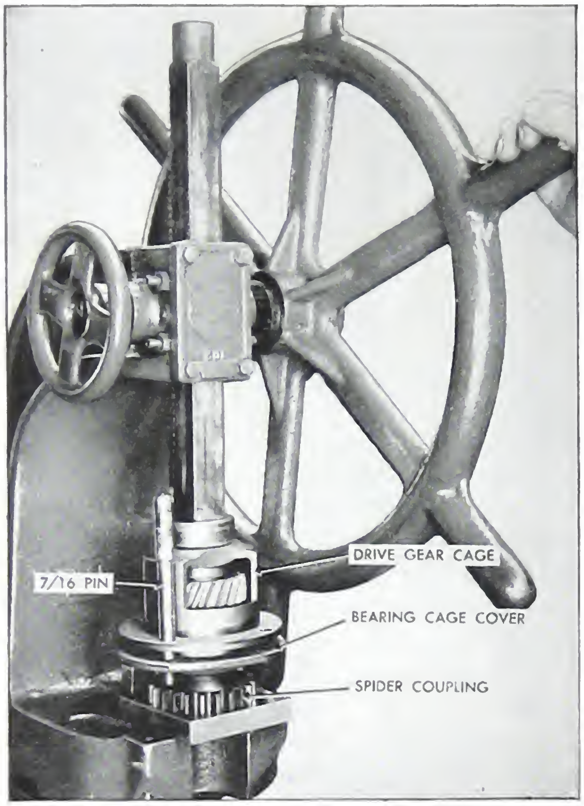

Fig. 9-2. Assembling generator and compressor drive

4. Assemble the fan drive pulley hub key on the end of the shaft.

5. Press the ball bearing in the spider end of the housing to the shoulder and lock in place with the snap ring.

6. Press the oil seal, with sealing lip toward ball bearing, into the housing and flush with the end of the housing.

7. Put the rubber pack ring in the groove on top of the housing.

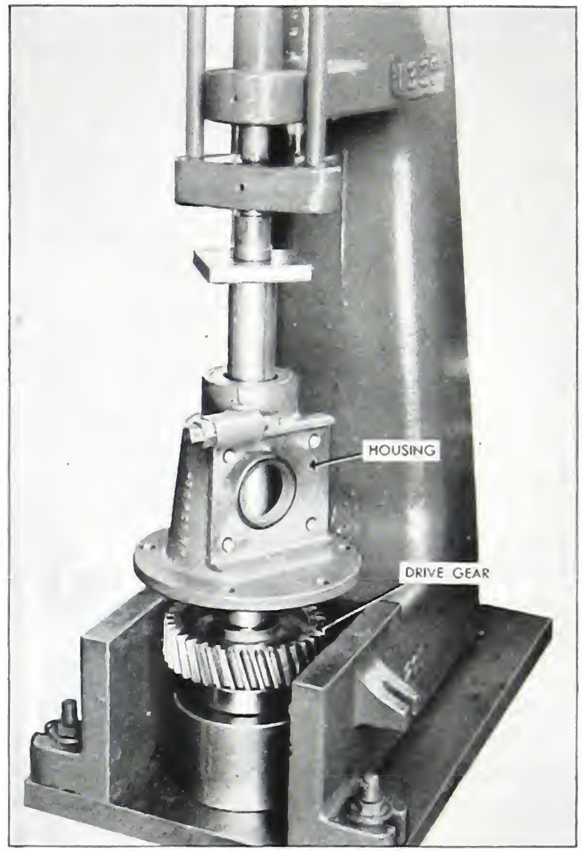

Fig. 9-3. Assembling fuel pump and compressor drive

8. Assemble the compressor adjusting screw and lock nut to the housing.

9. Press the housing assembly on the shaft and gear assembly to the stop. Fig. 9-3.

10. Assemble pulley, or spacer, to the coupling end of the shaft.

11. Assemble the spider over the key on the shaft. Lock with nut and washer.

SECTION X

UNITS No. 10 and No. 11

Intake System — Exhaust System

The intake system consists of air filters and silencers, supercharger and connections, preheater and air intake manifold.

The exhaust system consists of the exhaust manifold, exhaust piping, exhaust silencer and mufflers.

DISASSEMBLY AND CLEANING

Air Filters

1. Disassemble air filters and/or air silencers.
2. Air cleaner screens should be cleaned by using steam then sloshed in fuel oil to remove any remaining dirt particles and to prevent rust. After cleaning dip in clean lubricating oil.
3. Wash filter screen in a clean solvent and dip in light lubricating oil.
4. Wash out filter cases and tubes.

Supercharger

It is recommended that the supercharger be removed from the engine and be completely dismantled every 3,000 working hours regardless of previous inspection. It is very important that all oil seals and worn bearings be replaced at this time.

INSPECTION BEFORE DISASSEMBLY: 1. Ordinarily it is more economical to replace a worn-out supercharger with a factory exchange than to completely rebuild the old one.

2. If supercharger rotors or case are scored, or

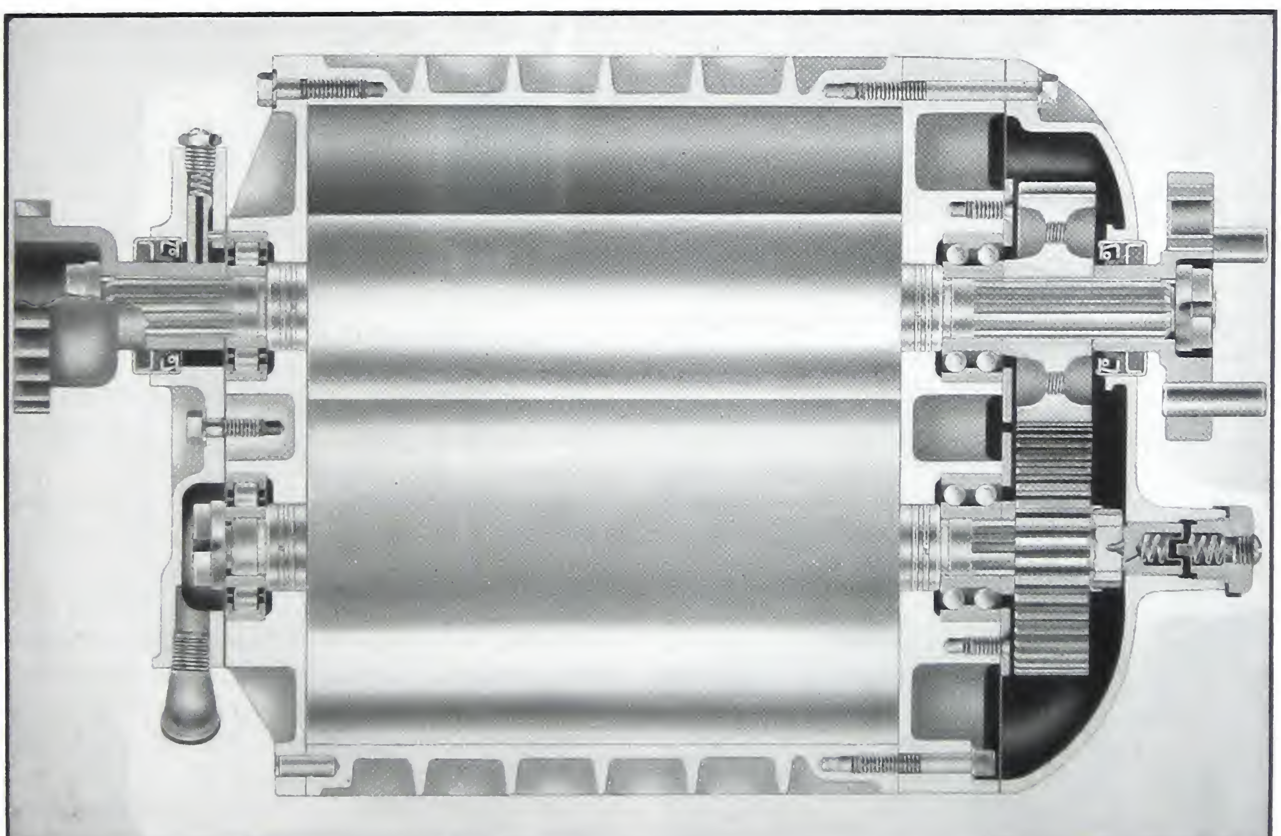

Fig. 10-1. Supercharger—cross section

broken from any cause, it is best to get a factory rebuilt supercharger. This inspection can be made through inlet and outlet ports, thus removing the necessity of useless disassembly.

3. Proper bearing replacement and other preventive maintenance will, in nearly all cases, prevent expensive rotor and casing replacements.

SERVICE TOOLS: In addition to the hand tools that are available to the average mechanic, certain special tools must be used in replacing bearings and oil seals in the supercharger. To completely disassemble the supercharger, use special tools as pictured and included in Service Tool Kit ST-107.

Supercharger

DISASSEMBLY: The supercharger is a closely fitted unit. Extreme care must be exercised throughout the operations to insure a satisfactory working unit after repair and assembly to the engine. Particular attention must be given to clearances and to installation of the oil seals.

1. With the intake and discharge ports covered, wash the exterior of the supercharger thoroughly before disassembly.

CAUTION: DO NOT USE ANY SOLUTION THAT WILL DAMAGE THE FINISHED SURFACES.

2. Remove the oil pressure connection fitting, spring and metering pin from the bearing cover. See Fig. 10-1.

3. Pry the rim of the lockwasher up out of the slot in the generator drive sprocket locknut. Lock the rotors with the drive coupling locking wrench and remove the locknut and lockwasher

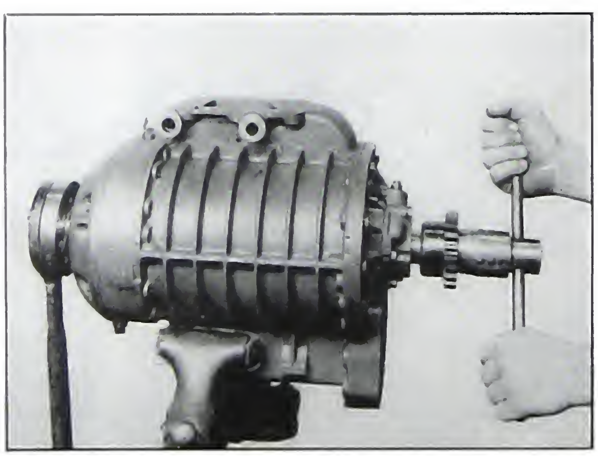

Fig. 10-2. Removing generator drive sprocket locknut

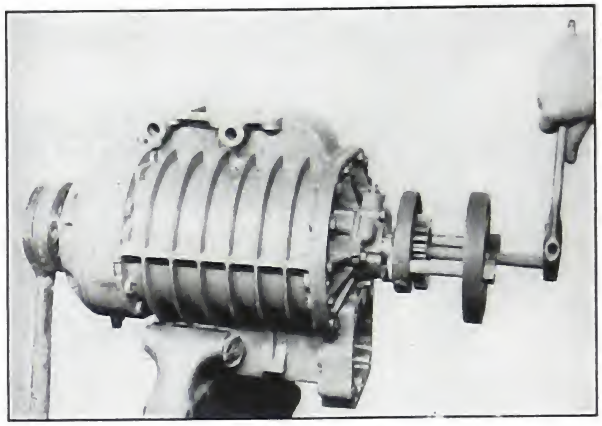

Fig. 10-3. Pulling generator drive sprocket

from the generator drive sprocket. See Fig. 10-2.

Remove the generator drive sprocket with the special puller. See Fig. 10-3.

4. Remove the capscrews from the bearing cover. With a small screw driver at each end of the cover, carefully pry the cover loose from the dowels. After removing bearing cover drive out oil seal.

5. Pry the ears of the lockwasher up and out of the slots in the locknut on the rotor shafts at the plain end of the supercharger and also on the drive coupling locknut at the gear end of the supercharger. Lock the rotors with the coupling locking wrench and remove the locknut at the plain end and the locknut in the drive coupling.

6. With the puller, remove the drive coupling from the shaft.

7. Remove the drain plug from the bottom of the gear cover and drain the oil.

8. Remove the capscrews from the gear cover and take off the cover. Remove oil metering plunger and spring from the gear cover. Remove oil seal. See Fig. 10-1.

9. Remove the locknut and lockwasher from the idler rotor shaft end using the shaft locking wrench to lock the rotors. See Fig. 10-4.

10. Remove the socket head capscrews from the gear-end end plate. Remove the end plate, rotor and gears as a unit from the housing. Carefully tap the plate at each end with a rubber hammer to remove it from the housing dowels.

11. Support under side of end plate in close to rotors and press each rotor shaft out. Mark each gear so it can be replaced on the same shaft from which it was removed. See Fig. 10-5.

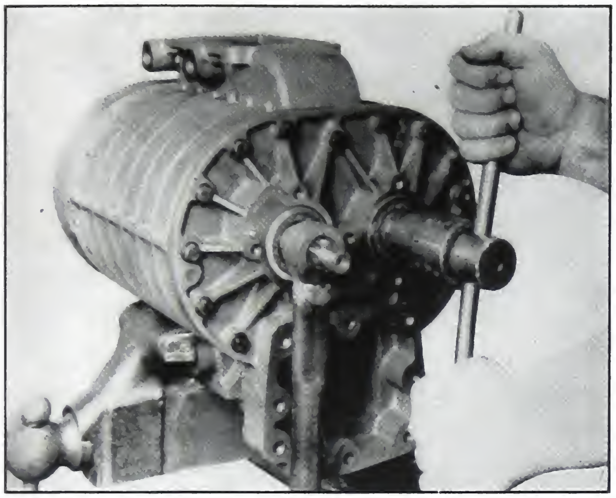

Fig. 10-4. Removing locknuts

12. When rotors are removed from the housing the inner races of the roller bearings usually remain on the shafts. Remove them carefully, avoiding damage to the shafts.

13. Remove the three screws from each bearing retainer plate on the gear-end end plate and remove retainers. See Fig. 10-10.

14. Press bearing out of gear-end end plate.

15. Remove the cap screws from the plain-end end plate. Remove the end plate from the housing dowels by carefully tapping the plate at each end with a rubber hammer.

16. Drive the bearing outer races and rollers out of the end plate.

Pre-Heater Or Flame Thrower

1. Disassemble the pre-heater. Remove the electrodes from the housing.

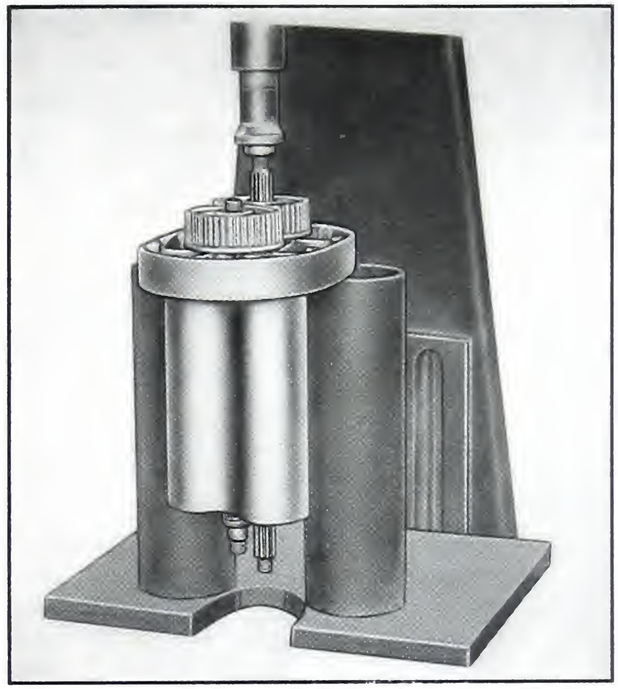

Fig. 10-5. Removing rotor and gear

2. Clean the electrodes by buffing with a wire brush.
3. Clean the pre-heater housing.
4. Clean the pre-heater nozzle and make sure it is tight in the adapter.
5. Clean pre-heater filter, if used, by reverse flushing with Kerosene.

Intake And Exhaust Manifolds

1. Steam clean intake and exhaust manifolds to remove all dirt and carbon accumulations.
2. Water cooled exhaust manifolds should have all lime or salt accumulations removed in special solvent tank with heated acid type cleaner.

INSPECTION

Air Filters And Silencers

Inspect air filter cases, screens and connections and replace defective parts with new ones.

Pre-Heater

1. Inspect the electrodes and replace if points are burned or if porcelains are cracked.
2. Inspect the pre-heater housing for cracks.
3. Inspect the pre-heater coil and connections.
4. Operate the pre-heater fuel pump for suction and discharge. Mark for repair or replacement as needed.

Supercharger Connections

Inspect supercharger connections for cracks. Replace old gaskets and seal rings with new parts.

Intake And Exhaust Manifolds

1. Inspect intake manifold, exhaust manifold sections and flanges for cracks and distortions and indicate necessary replacements.

2. Water test marine type water cooled exhaust manifold at 30-80 psi. pressure.

Supercharger

1. Clean and inspect all parts. Any broken or excessively worn parts must be replaced with new ones.

2. The following parts should always be replaced with new ones whenever unit is disassembled:

a. Two double row ball bearings.
b. Two roller bearings.
c. Oil seals.
d. Bearing cover gasket.
e. Gear cover gasket.
f. Four rotor shaft lockwashers.

3. Inspect the rotors, housing and end plates for cracks, abrasions, wear spots and build-ups of foreign material. Cracked castings should be replaced with new ones. Rough or worn spots should be smoothed out with fine emery cloth and all built-up deposits of gum, carbon, etc., should be removed. The parts should then be washed clean and dried. Rotors and shafts are not separable and must be replaced as a unit.

4. The following parts should be checked for excessive wear:

A. Generator flange should be replaced if the hub diameter is visibly worn or grooved under the oil seal, or if the sprocket teeth are worn or broken.

B. Drive coupling should be replaced if the hub diameter is visibly worn or grooved under the oil seal.

C. The rotor timing gears should be checked for backlash on 4.000 centers with the gear teeth clean and dry. If the backlash exceeds .004, new gears should be used.

On blowers with old style two-piece gears (Serial numbers up to 40-97-SL9500 and up to 40-97-R700) new rotors, shafts and gears must be used if any one of the parts is worn or broken.

On blowers with new one-piece gears (Serial numbers 40-97-L9500 and up and 40-97-R700 and up), new timing gears only are required if the rotors and shafts are otherwise in good condition.

D. The gear and coupling splines should be a press fit on the rotor shaft splines. New rotors and gears should be used if this spline fit is not tight.

E. Bearing spacers should be replaced if the outside diameter is visibly worn or grooved.

F. Drive rotor shaft ends should be checked for runout. Mount the rotor and shaft assembly on the bearing journals and indicate the outside diameter of the splines at the shaft ends. The runout should not exceed .001 total indicator reading.

G. If the coupling drive pins or bushings show wear, press them out and replace with new pins and bushings in both the engine and supercharger halves.

H. Broken piston rings or seals must be replaced, where used.

REBUILDING AND ASSEMBLY

Air Filters And Silencers

1. Dip air filter or air intake silencer screens in SAE No. 20 lubricating oil.

2. Install the filter screen. Secure in place with washer and nut.

Supercharger

1. Soak new oil seals in lubricating oil and assemble in the two end plates with the sealing lip pointing *away* from the rotors. Assemble the oil seals in the gear cover and bearing cover with the sealing lip pointing *toward* the rotors. If oil seals are not assembled in the proper position, oil leaks may result which could cause damage to the engine.

2. Assemble piston rings in rotor shaft grooves. Piston ring seals are used in superchargers after Serial No. 20,000.

3. Use a block of wood to hold the rotors for preliminary assembly and for checking end clearance. See Fig. 10-6. Assemble rotors in wood

block with gear ends up. Where piston ring seals are used be careful not to damage them on the block.

4. Assemble a bearing spacer to each rotor shaft and assemble gear-end end plate to the rotor shafts as shown in Fig. 10-7.

5. Assemble new double row ball bearings to the rotor shafts as shown in Fig. 10-8 with the bearing name to the outside. Drive bearings into end plate bearing pockets using special driving mandrel.

6. Assemble the bearing retainers to end plate with lockwashers and flat head screws. See Fig. 10-10.

7. Assemble each rotor into proper bearings in gear end plate carefully to avoid breaking the piston ring seals. See Fig. 10-7.

8. To check end clearance between rotors and end plate, use temporary spacers on the shafts and tighten in place with the shaft locknuts as shown in Fig. 10-10.

Position the rotor holes so that they lock against each other while tightening locknuts.

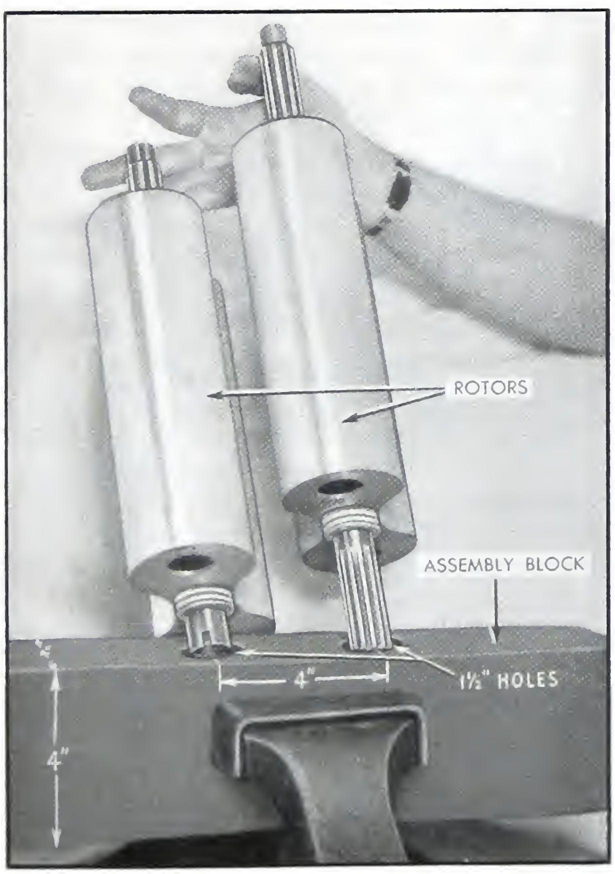

Fig. 10-6. Assembly block

9. With a feeler gage check the clearance between the rotors and end plate as shown in Fig. 10-9. This clearance should be .005 to .006. Bearing spacers or steel shims are available in steps of .002, .003 and .005. The proper spacer or shims should be used to obtain the .005-.006 end clearance. Use between shaft shoulder and bearing inner race.

10. Assemble the rotors and end plate to the housing. Replace the socket head capscrews and lockwashers in the end plate and tighten securely.

NOTE: Steps 10, 11, 12 and 13 apply to superchargers before Serial No. 20,000.

11. With new oil seals in place, assemble the plain-end end plate to the housing. Assemble the lockwashers and capscrews and tighten securely.

12. Assemble *new* roller bearings in the end plate with the name to the outside.

13. With feeler gages inserted through the inlet and outlet ports, check the clearance between the rotor lobes and the housing bore. This clearance should be .005 minimum on the *outlet* side and .007 minimum on the *inlet* side. The clearance between the rotors when they are perpendicular to each other should be .006 minimum. See Fig. 10-11.

Check the plain end plate clearance as shown in Fig. 10-12. This should be .007 minimum.

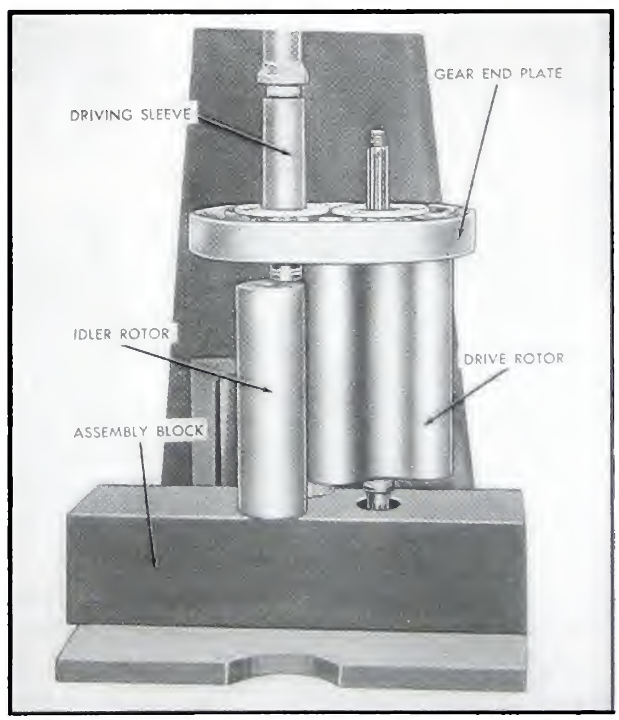

Fig. 10-7. Pressing rotors in gear end plate

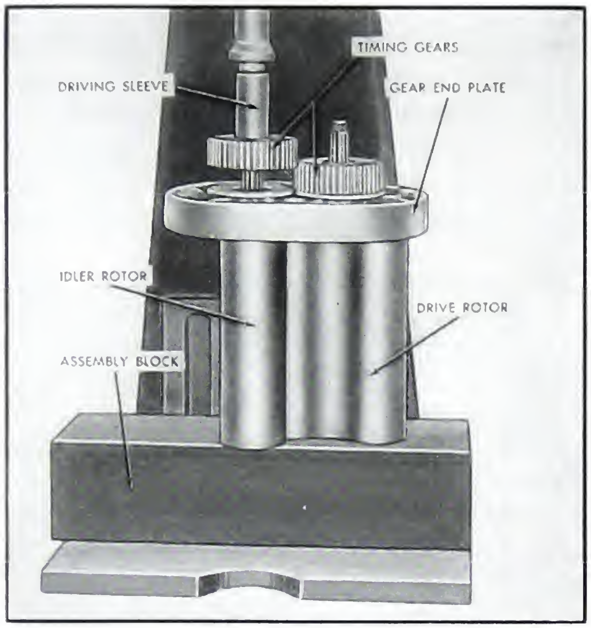

Fig. 10-8. Pressing gear in place

CAUTION: DO NOT PROCEED FURTHER WITH ASSEMBLY UNLESS THESE CLEARANCES ARE OBTAINED, OTHERWISE EXCESSIVE WEAR ON THE BEARINGS WILL ALLOW THE ROTORS TO STRIKE EACH OTHER OR THE HOUSING OR END PLATES. IF THESE CLEARANCES CAN NOT BE OBTAINED, THE SUPERCHARGER SHOULD BE RETURNED TO THE FACTORY FOR RECONDITIONING.

14. Separate inner races from new roller bearings and drive the inner races on the plain end of the rotor shafts.

NOTE: Steps 14, 15, 16 and 17 apply only to superchargers after Serial No. 20,000.

15. Assemble rotors, end plate and gears to the housing. Replace the socket head screws and lockwashers in the end plate and tighten securely.

16. Assemble the plain-end end plate to the housing. Assemble the lockwashers and capscrews and tighten securely.

17. Assemble new roller bearing outer races with rollers in the end plate with name to outside.

18. Remove the temporary assembly spacers from the drive ends of the rotor shafts and assemble the timing gear to the drive rotor shaft by supporting assembly on shaft or rotor at opposite end and pressing gear on spline with an arbor press. Replace same gear on drive shaft which was originally removed from it. See Paragraph 11, Disassembly Section, Page 10-3.

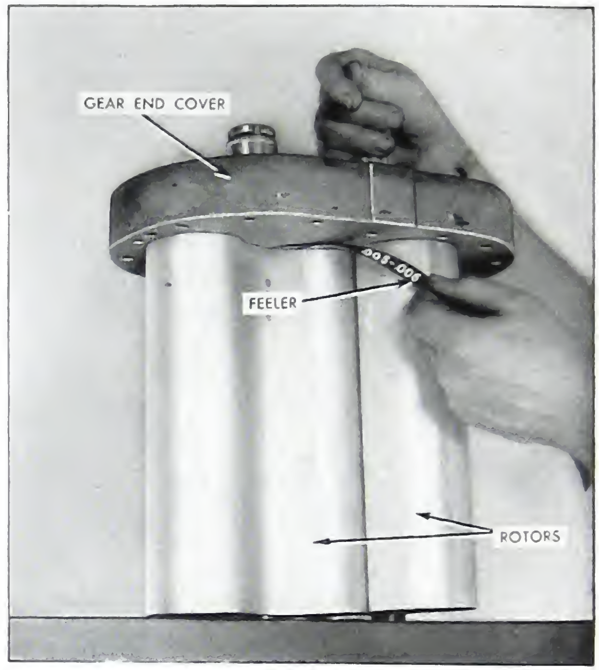

Fig. 10-9. Gear End Plate Clearance

19. With the rotors set at 90° apart press on the idler gear, supporting the assembly on idler shaft or rotor at opposite end. Make certain that the rotors are timed correctly and that the two gears are meshing properly as the idler gear is being pressed on the shaft.

20. Lock the rotors with the special shaft locking wrench and replace the idler gear lockwasher and locknut. The tang on the inner part of the lockwasher should fit into the keyway in the shaft. With a small punch force the rim of the lockwasher down into one of the slots in the locknut after the locknut has been tightened securely.

21. Replace the oil metering plunger and spring in the gear cover. The small hole in the plunger must be clean. The slots in the plunger should be lined up with the prongs on the spring retainer fitting or the cover will not pull up against the end plate. See Fig. 10-1.

22. With a new oil seal in place, assemble the gear cover to the end plate. Use a new gear cover gasket. Replace the lockwashers and cap screws. Tighten securely.

23. Support the assembly on the drive rotor shaft on the plain end and press the drive coupling on the shaft. Apply pressure on the coupling flange, *not* the drive pins.

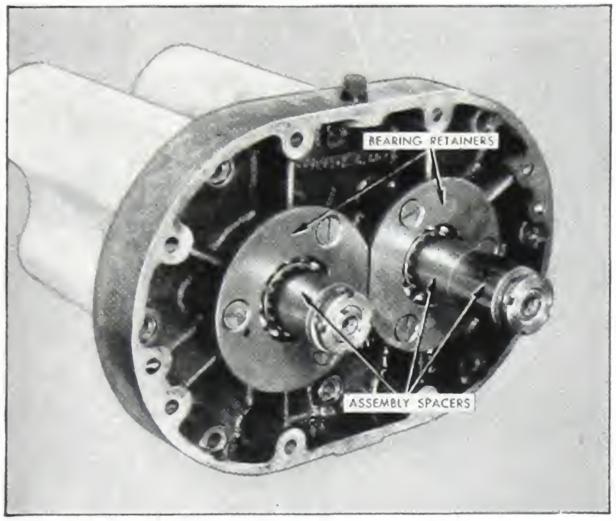

Fig. 10-10. Bearing Retainers and Temporary Assembly Spacers

24. With the special locking wrench in place on the drive coupling, assemble shaft lockwasher and locknut. Tighten securely. Lock the lock-washer into nut slot.

25. Replace idler rotor shaft lockwasher and locknut at the plain end. Tighten securely and lock.

26. Using a new bearing cover gasket with a new oil seal in place assemble the bearing cover to the plain-end end plate. Replace the lockwashers and capscrews and tighten securely.

27. Press the generator drive sprocket on the shaft. While pressing on the sprocket, always rest the unit on the opposite end of the shaft.

28. Replace generator sprocket lockwasher and locknut. Tighten securely and lock.

29. Replace the oil metering pin, spring and fitting in the bearing cover. The radius of the metering pin must correspond to the radius of the coupling hub. It must work freely. The hole in the metering pin must be clean and line up with the slot in the hub. See Fig. 10-1.

30. Assemble the oil drain fitting in the gear-end cover.

31. Turn drive coupling by hand to see that rotors rotate freely.

32. After assembling supercharger to engine, remove oil filler plug from top of gear-end end plate and add one quart of engine lubricating oil. Replace filler plug.

Supercharger Coupling

SUPERCHARGER COUPLING HALVES, NO. 42379 AND NO. 42380: 1. These supercharger coupling halves are made to closer tolerances than the couplings formerly used and matching of halves is not necessary. It is necessary that the engine half-coupling, No. 42379, always be used with the supercharger half, No. 42380.

2. No. 67554 bushings are to be used in these coupling halves.

3. Press old worn bushings out of the halves

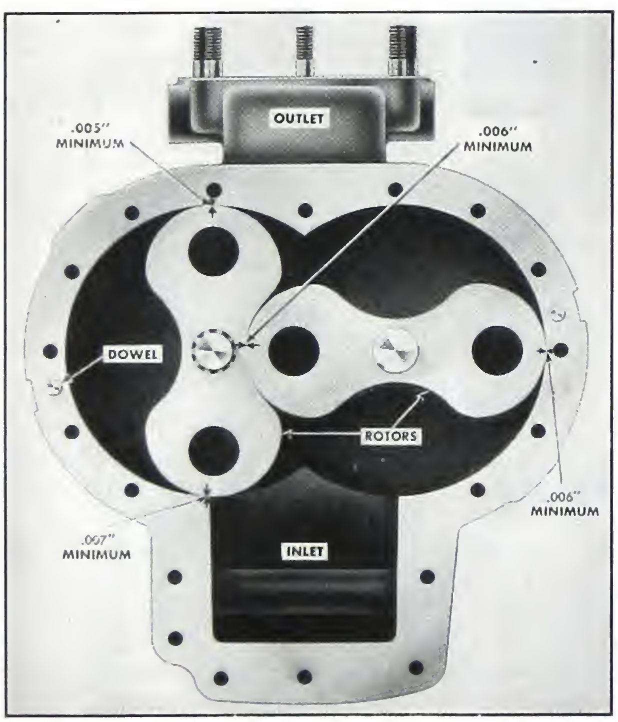

Fig. 10-11. Supercharger clearances—minimum

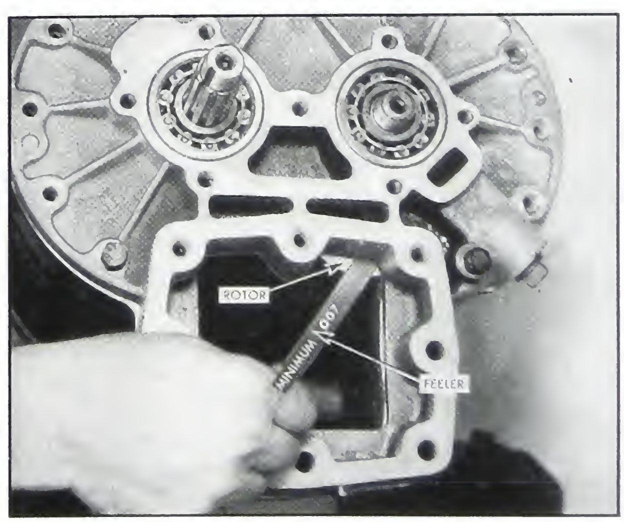

Fig. 10-12. Plain end plate clearance

with a mandrel and press in the new steel cased bushings.

4. If pins are worn, press out the old pins and press in new No. 67555 pins.

Pre-Heater And Air Intake Manifold

1. Rebuild or replace the fuel priming pump as indicated. Some models of these pumps can be repaired by new packing leather or rings.

2. Assemble the electrodes to the pre-heater housing and adjust for a spark gap of 3/32".

3. Replace spark coils, wiring and switches as needed.

4. A fuel filter No. 70070 is available for use between the priming pump and preheater nozzle. This filter will aid in prevention of clogged nozzles and can be added in the fuel line very easilv.

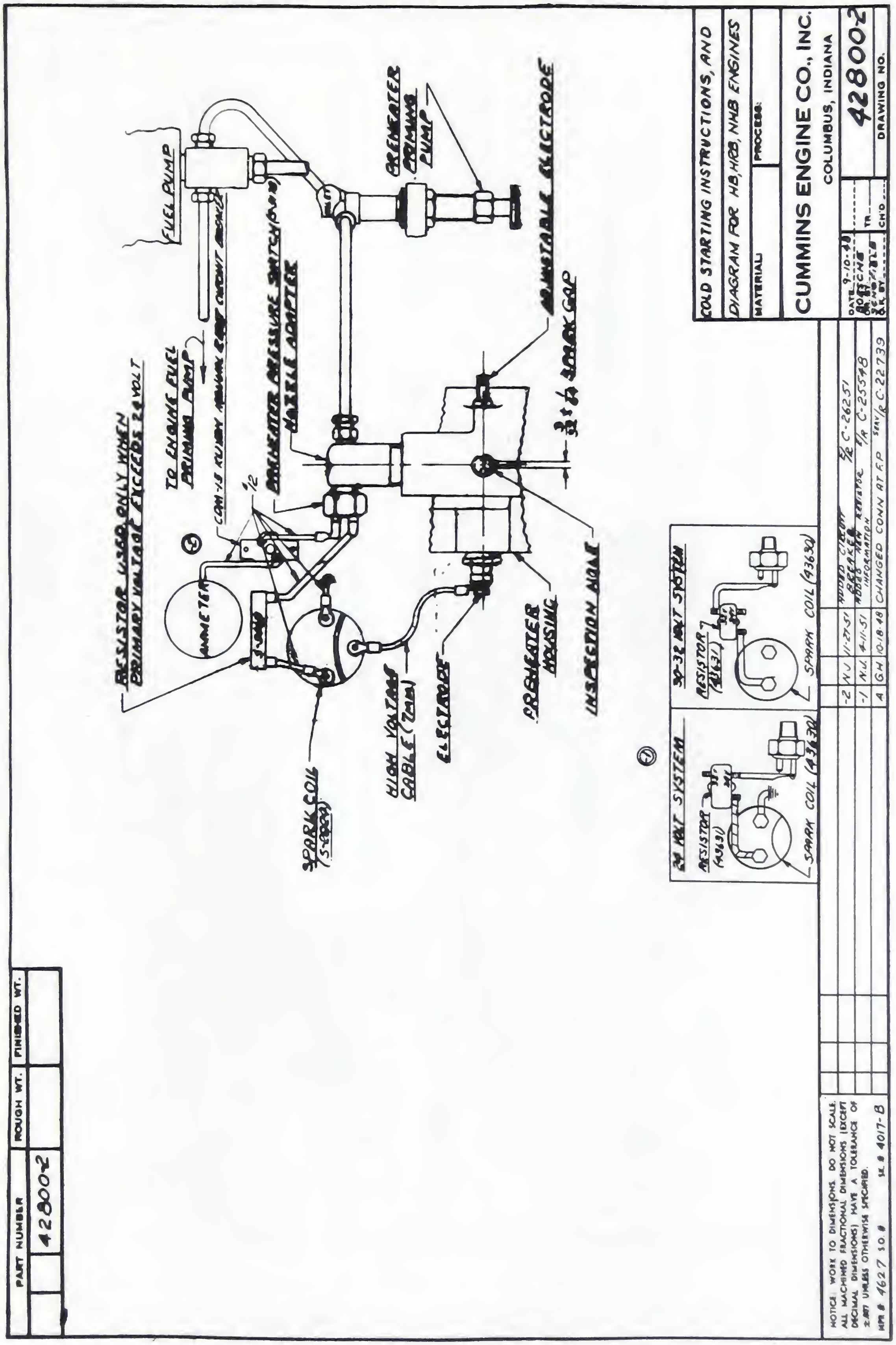

Fig. 10-13. Cold starting diagram—preheater with electrodes and spark coil

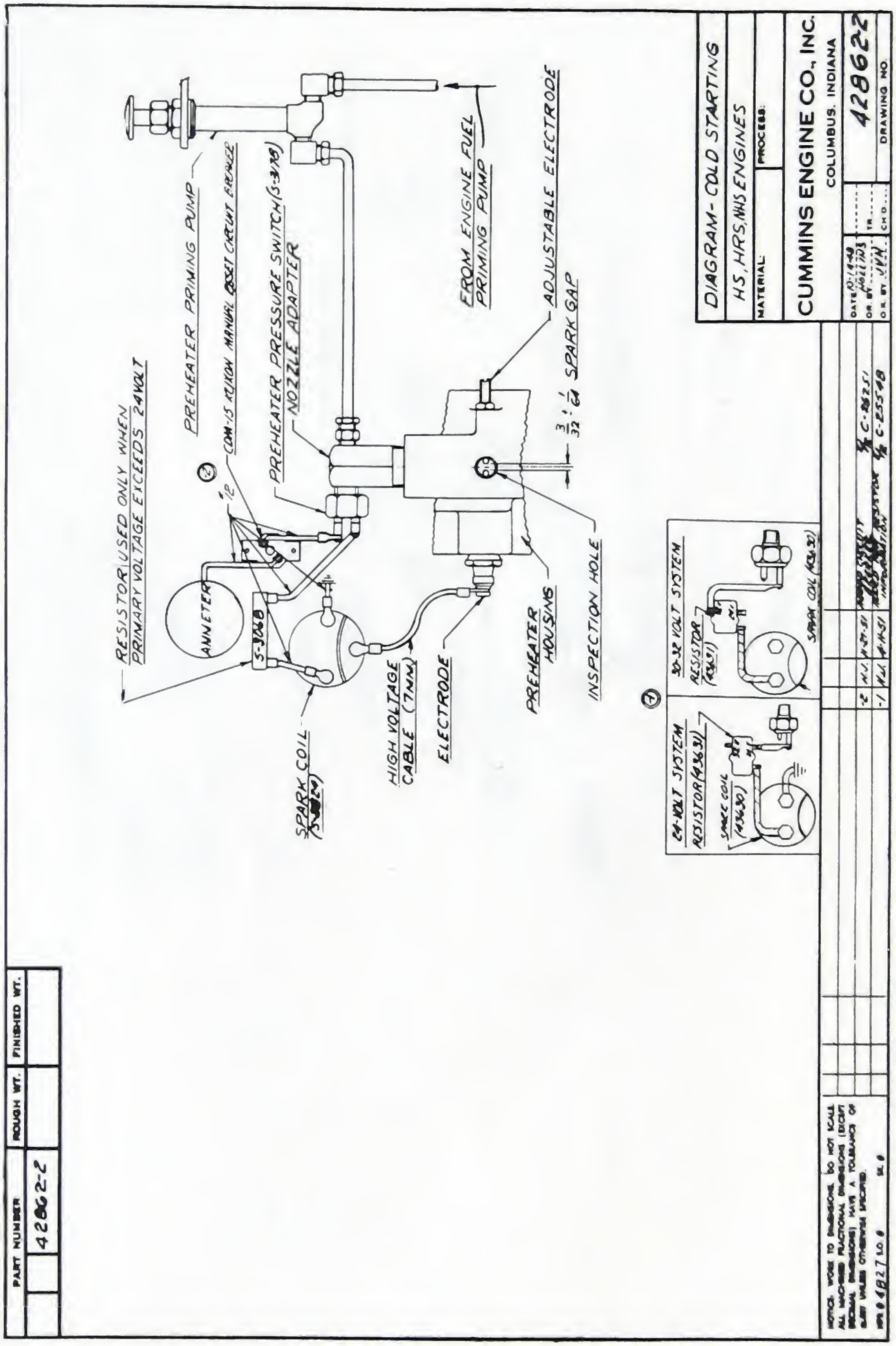

Fig. 10-14. Cold starting diagram—preheater with spark coil and electrodes

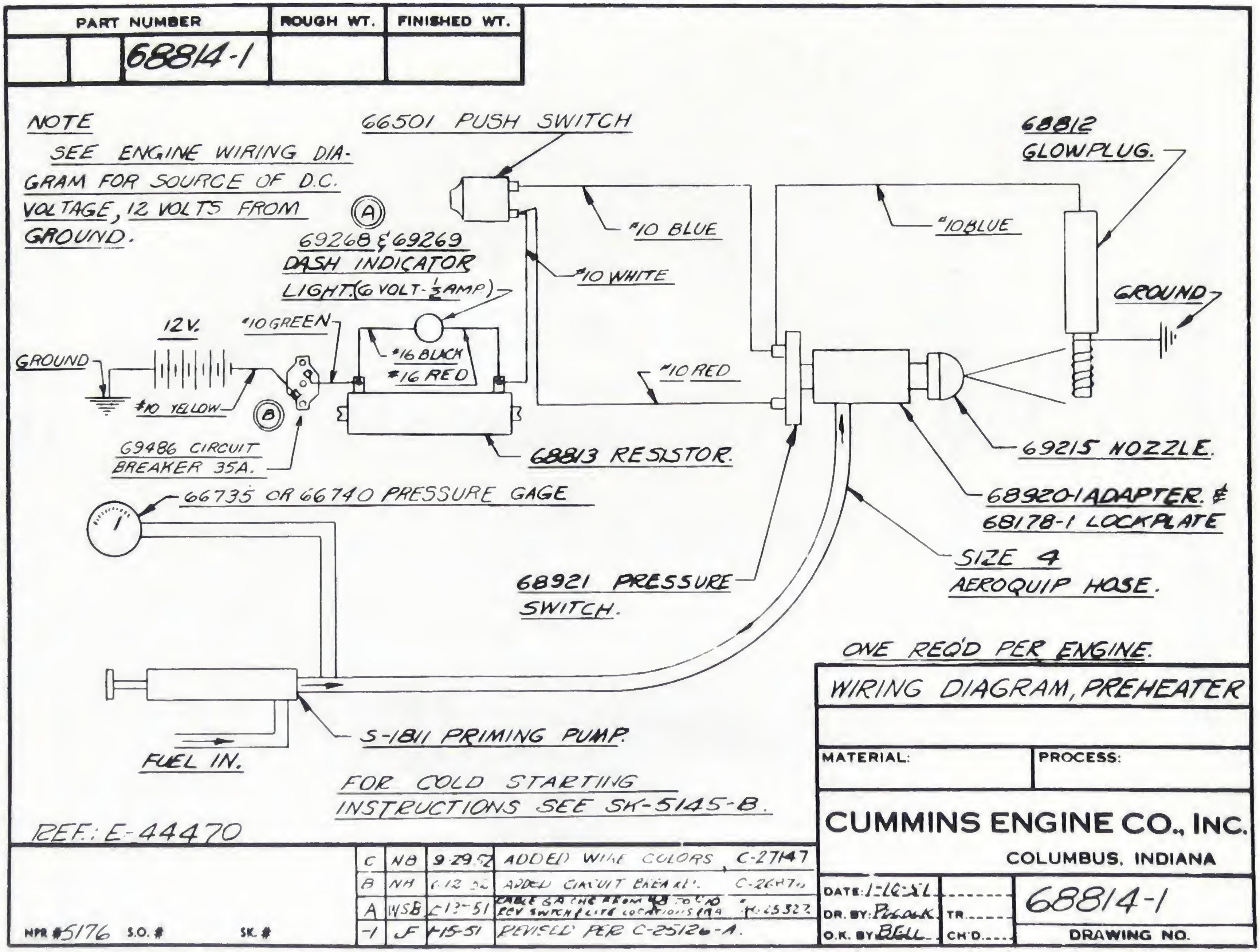

Fig. 10-15. Cold starting diagram—preheater with glow plug

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SECTION XI
UNITS NO. 12 AND NO. 13

Accessory Equipment

AIR STARTING AND BRAKING

UNIT NO. 12: Equipment included under "Air Starting and Braking" includes the air compressor and vacuum pump. It is recommended that worn out air compressors be exchanged for manufacturer rebuilt units. Therefore no instructions for rebuilding equipment in Unit No. 12 will be included in this manual.

ELECTRICAL EQUIPMENT

UNIT NO. 13: This unit includes:

- Electric Connections
- Cranking Motor
- Magnetic Switch
- Starting Switch
- Generator
- Voltage Regulator
- Solenoid and Step Controls
- Engine Wiring
- Electric Gauges

The information contained in this unit section is limited to a brief description of the function and operation of electric units used on Cummins engines and to simple tests and adjustments that can be made without special equipment. Wiring diagrams for installation work and parts replacement are also included.

It is recommended that repair of electric units be done in manufacturers' service stations. Their stations are well equipped and well distributed.

If this service is not available further specific information can be obtained as follows:

DELCO-REMY EQUIPMENT: Electrical Equipment Operation and Maintenance Handbook DR-324 and Test Specification DR-324-S may be purchased from the nearest United Motor Service Station, or the Service Dept. Delco-Remy Division, General Motors Corp., Anderson, Indiana.

LEECE-NEVILLE EQUIPMENT: Operation and adjustment information may be purchased from the nearest Leece-Neville distributor or the Service Dept. of the Leece-Neville Co., 5109 Hamilton Ave., Cleveland 14, Ohio.

Electric Connections

An electric current travelling through a wire may be compared to water flowing through a hose or pipe. The voltage in the electric circuit is like the pressure behind the water in the hose. Water pressure is lost if it is allowed to leak at connections or if the hose diameter is so small that it offers resistance to flow. This loss of water pressure compares with loss of electric pressure, or voltage, because of poor connections or conductors of insufficient capacity.

Most electric units, such as switches and regulators work around various applications of the electro-magnet which depends on the amount of voltage applied from the generator and battery. Therefore, it is important to avoid loss of voltage resulting from improper connections and wire which is too small.

Connections must be tight and splices should be soldered and insulated so no voltage loss will occur at these points.

The following practices are recommended to assure efficient operation of the electric system. They are especially necessary in cold weather when the starting requirements are higher and the battery capacity is lower than normal:

1. Generator-Regulator-Battery circuits should be two-wire circuits on all systems having 10 or more amperes generator capacity.
2. Starting motors—battery circuits should be two-wire circuits of No. 00 B & S gauge size or larger. This is especially important for cold weather starting.
3. Any accessory circuits which are of the one-wire ground-type should have ground connections as described in this Manual.

GROUND CONNECTIONS: In engine applications, a common ground connection is sometimes used. This system uses the metal of the unit as

one side of the electric circuit and, as such, makes all metal which lies between the electric unit and the battery or generator, an electric conductor. So, it is advisable to make all ground connections to the same solid metal member.

An occasion may arise when the battery is grounded to one beam of the frame and it is necessary for you to make ground connections to a second beam or section of the superstructure which is jointed to the first. This can be done safely if you first bolt and sweat solder a flexible, heavy, metal strap between the two beams to bridge the joint. This has the effect of making the jointed member a part of the beam which grounds the battery. All metal joints in the circuit should be treated in this manner. This will also hold true for instrument ground connections in the cab, on the instrument panel, etc.

Many engines and cabs are installed on rubber or other flexible mountings. These mountings, in themselves, provide practically no electric connection to the frame. Even a solid-type engine mounting in which the bell housing is bolted directly to the frame makes a poor electric connection. *All ground connections from any electric unit should be made to the same solid or bridged metal member to which the battery itself is grounded.*

Corrosion, as well as oil and dirt between the two surfaces, eventually has the same effect as a resistor placed in the wiring circuit. Never bolt ground wires to a rusty, greasy or dirty surface.

Regardless of where magnetic switches cut-out relays, and other control units are mounted, a separate ground wire should be run from the proper terminal or designated part of the unit to the same solid metal member grounding the battery. *Whenever it is possible, make ground connections directly to the battery's grounding bolt.* This will provide a dependable ground return circuit and permit an unretarded passage of the current to allow the units to function as they are intended.

The sketches shown here indicate only the proper method of grounding certain units. They are not complete wiring diagrams and, under no circumstance, should they be used as such.

To make a good electric connection between a cable terminal and the frame, you must clean and scrape the metal surfaces until they are bright and then tin these surfaces to prevent rust and corrosion. To make a completely dependable, permanent joint, after the cable is bolted to the frame, sweat solder the two together.

The heavy cables used to make ground connections from the battery, cranking motor or engine should be prevented from swinging. A single bolt connection as shown in Fig. 11-1 is unreliable. The surface of the frame at the joint is not tinned and, in addition, the heavy cable can swing back and forth to loosen the connection. Loose connections leave a space between the cable terminal and frame which may allow the entrance of dirt or moisture to form rust or corrosion.

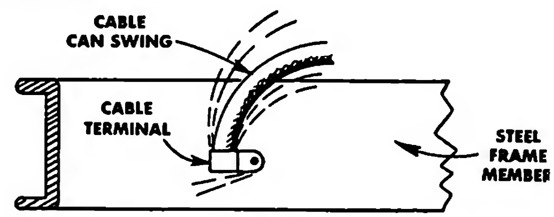


Fig. 11-1

Recommended ground connections and methods of preventing cable swing are shown in Fig. 11-2. The surface of the frame at the connection is tinned to prevent rust and corrosion.

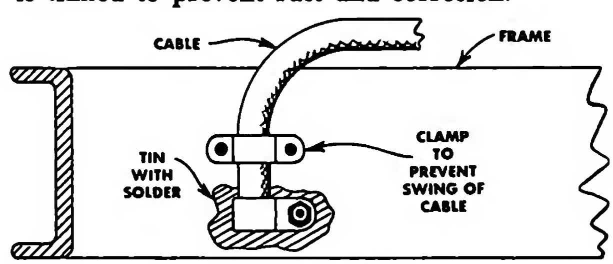


Fig. 11-2

Cranking Motor And Controls

The cranking motor used on diesel engines is a special overload motor capable of delivering a high horsepower for its size for short periods of time. In order to obtain this power from the unit without increasing the size, it is necessary to build the cranking motor with a minimum of resistance so a large current will be taken through it while cranking. It is consequently obvious that the cranking motor should be used for short periods only—approximately 30 seconds maximum to avoid the possibility of failure due to overheating.

CLEANING: All parts should be cleaned after disassembly. Do not clean the armature or fields in any degreasing tank, since the compounds used in this type cleaner may cause damage to mica or enamel insulation and rubber.

COMMUTATOR: 1. If the commutator is dirty, it may be cleaned with a strip of No. 00 sandpaper. NEVER USE EMERY CLOTH TO CLEAN COMMUTATOR.

2. All dust must be blown from the cranking motor after the commutator has been cleaned.

3. If the commutator is rough or out of round, or has high mica, remove the unit from the engine and disassemble the armature. Turn the commutator down in a lathe, removing only sufficient material to true up the commutator and remove roughness and high mica. Undercut the mica.

BRUSHES: Replace worn brushes. If brushes wear rapidly, check for incorrect brush spring tension and roughness or high mica on the commutator.

LUBRICATION: 1. All bearings provided with hinge cap or ball type oilers should have 8-10 drops of light engine oil every 5,000 miles. Grey iron or bronze bearings with grease cups should have the grease cups kept filled with medium cup grease and turned down one turn every 5,000 miles.

2. Ball bearings with grease cups should have the grease cups kept filled with ball bearing grease and turned down every 5,000 miles.

3. Oil plugs should be removed every 6 months and the reservoir packed with graphite grease. On tractor, marine, and stationary applications, lubricate as above every 300 hours of operation.

4. Do not lubricate excessively, since excessive oiling may cause oil and grease to gum on the commutator and reduce the cranking ability of the motor. Never oil the commutator.

5. On some models, oil wicks are used for lubrication of the center or drive-end bearing. The wick is saturated with oil before assembly. Whenever the cranking motor is removed from the engine, the oil wick should be saturated with oil before the unit is reinstalled.

6. All oilless-type bushings should be supplied with a few drops of light engine oil whenever disassembled.

7. Lubricate cranking motor drives with a few drops of light engine oil. Avoid excessive oiling.

CRANKING MOTOR CONTROLS: 1. Because of the high current flow from the battery to cranking motor during cranking, some positive means of connecting and disconnecting the battery and cranking motor must be used. The switch used must have contacts of adequate size to carry the current without burning. The manually operated switch mounted either on the floor board or the cranking motor frame, is the simplest type of switch.

2. Some applications with Bendix drive use a magnetic switch, a small electromagnet, which when energized draws in a plunger and causes a contact disc to make contact between two terminals to complete the circuit from the battery to cranking motor. The magnetic switch winding is usually energized by a dash push button.

3. Some applications with the overrunning clutch, or Dyer type drive, use a somewhat larger magnetic switch, called a solenoid switch, wherein the plunger not only thrusts against a contact disc to close the battery to cranking motor circuit, but the plunger is also linked to the shift lever so that the drive pinion is shifted into mesh with the flywheel teeth by the solenoid action. The solenoid switch is usually actuated by a dash push button.

4. Diesel engines and similar applications require a comparatively high voltage to insure adequate cranking performance. The series-parallel system is designed to provide a means of connecting two batteries in series to provide increased voltage for cranking, and reconnecting the two batteries in parallel for normal operation of the equipment after starting of the engine has been accomplished. See Fig. 11-3.

CRANKING MOTOR DRIVES: Friction Clutch Type Bendix Drive: 1. This type of drive functions in much the same manner as other Bendix drives excepting that it uses a series of spring-loaded clutch plates which slip momentarily during the shock of engagement to relieve the shock and prevent it from being carried back through the cranking motor. The slipping stops as engagement is completed so that cranking torque is transmitted from the cranking motor armature through the drive pinion to the engine flywheel.

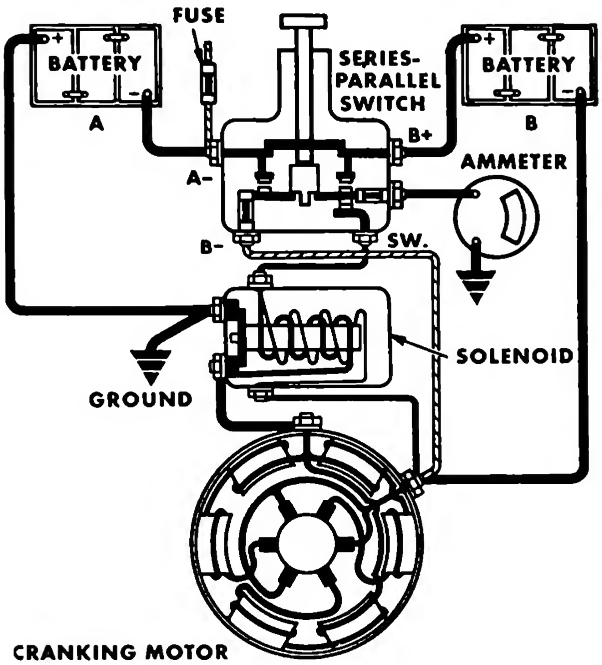


Fig. 11-3. Series-parallel switch circuit, shown in cranking position, with the series connections

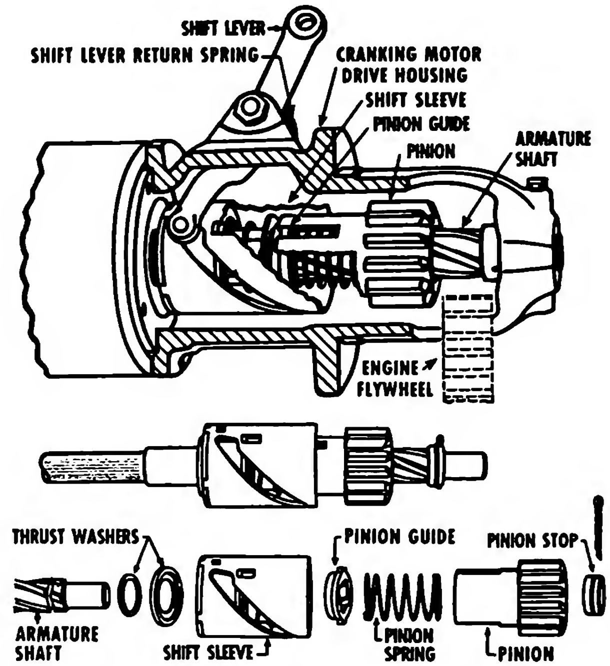


Fig. 11-4. Dyer drive assembly. Lower view shows exploded view of component parts

2. The pinion of the Bendix drive is mounted on a threaded sleeve which matches internal threads in the pinion. When the armature revolves, carrying the threaded sleeve with it, the inertia of the pinion does not allow it to pick up speed as rapidly as the armature. The result is that the treaded sleeve turns within the pinion, moving the pinion endwise and into mesh with the flywheel teeth so that cranking is accomplished. The spring-loaded clutch takes up the sudden shock of meshing. When the engine begins to operate, the flywheel drives the pinion at a higher speed than the threaded shaft is revolving. This causes the pinion to be turned relative to the threaded shaft, and in such a direction that the pinion is demeshed from the flywheel teeth.

THE DYER SHIFT DRIVE: 1. The Dyer drive provides for positive meshing of the drive pinion with the flywheel before the cranking motor switch is closed and before the armature begins to rotate. This reduces clashing of pinion teeth with flywheel teeth and the possibility of broken or burred teeth on either the engine or flywheel or the drive pinion. See Fig. 11-4.

2. The Dyer drive mechanism consists of thrust washers, a shift sleeve, pinion guide, pinion spring, pinion, pinion stop and cotter pin. The pinion guide is a snug fit on the spiral splines of the armature shaft, while the pinion, which has internal splines matching the armature splines, fits loosely on the armature shaft splines.

3. In the position shown in Fig. 11-4, the drive assembly is at rest. The drive pinion is retained in this position by the pinion guide which drops into milled notches in the armature shaft splines. The pinion can be released from this position only by movement of the pinion guide through operation of the shift lever.

4. When the shift lever is operated, the movement causes the shift sleeve, pinion guide, pinion spring and pinion to be moved endwise along the armature shaft so the pinion meshes with the flywheel teeth, provided the teeth align properly. Further movement of the shift lever closes the cranking motor switch, and cranking takes place. If the teeth are not aligned and meshing cannot take place at once, the pinion is rotated against the flywheel teeth until the teeth do align and meshing is accomplished.

OVERRUNNING CLUTCH DRIVE: 1. The overrunning clutch is designed to provide positive meshing and demeshing of the drive pinion and

flywheel ring gear. It uses a shift lever which slides the clutch and drive pinion assembly along the armature shaft so it can be meshed and demeshed as required. The clutch transmits cranking torque from cranking motor to the engine flywheel but permits the drive pinion to overrun, or run faster than, the armature after the engine is started. This protects the armature from excessive speed during the brief interval that the drive pinion remains in mesh.

2. The overrunning clutch (Fig. 11-5) consists of a shell and sleeve assembly which is splined internally to match splines on the armature shaft. Thus, both the shell and sleeve assembly and armature shaft must turn together. A pinion and collar assembly fits loosely into shell, and the collar is in contact with four hardened steel rollers which are assembled into notches cut in the inner face of the shell. These notches taper inward slightly so that there is less room in the end away from the rollers than in the end where the rollers are. The rollers are spring loaded by small plungers.

3. When the shift lever (Fig. 11-5) is operated, the clutch assembly is moved endwise along the armature shaft so that the pinion meshes with the flywheel ring gear. If the teeth should butt instead of mesh, the clutch spring compresses so that the pinion is spring loaded against the ring-gear teeth. Then, when armature begins to rotate, meshing takes place at once. Completion of the shift lever movement closes the cranking motor switch so that the armature begins to rotate. This rotates the shell and sleeve assembly causing the rollers to jam tightly in the smaller sections of the shell notches. The rollers jam between the pinion collar and the shell so that the pinion is found to rotate with the armature and crank the engine.

4. When the engine begins to operate, it attempts to drive the cranking motor armature, through the pinion, faster than the armature is rotating. This causes the pinion to rotate with respect to the shell so that it overruns the shell and armature. The rollers are turned back toward the larger section of the shell notches where they are free, and thus, permit the pinion to overrun. This protects the armature until the automatic controls take over so that the shift

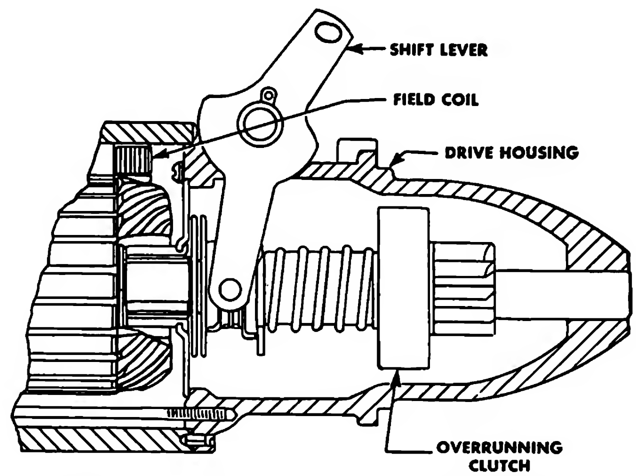


Fig. 11-5. Overrunning clutch drive assembly

lever is released, causing the shift lever spring to pull the overrunning clutch drive pinion out of mesh from the engine flywheel ring gear. This shift lever movement also opens the cranking motor switch so that the armature stops rotating.

5. The overrunning clutch pinion requires the same ring gear as the Bendix pinion.

FLYWHEEL RING GEAR: 1. The Dyer pinion should be used with a Dyer type ring gear. Fig. 11-6 shows the chamfer of the teeth for different arrangements. Where more than one attempt is necessary for making engagement of the pinion it is usually due to burred flywheel teeth. When flywheel ring gears are replaced, the Bendix type gear should never be used with a cranking motor on an engine having a Dyer type drive.

2. On a cranking motor having a Dyer drive, the armature shaft is splined. If the cranking motor rotation is clockwise, viewed from the drive end, the spline is right handed. If the rotation is counter-clockwise, the spline is left handed. The pinion rotates slightly as it moves forward to engage with the flywheel. If the wrong chamfer arrangement is used, the tip of the pinion teeth may butt the flywheel teeth on the chamfered side. In this event, it is necessary for the pinion to move one tooth farther from the point the pinion tries to engage with the flywheel. Refer to Fig. 11-6 showing butt end engagement of the Dyer pinion with the Bendix type ring gear. Engagements of this kind not only require repeated attempts for engagement

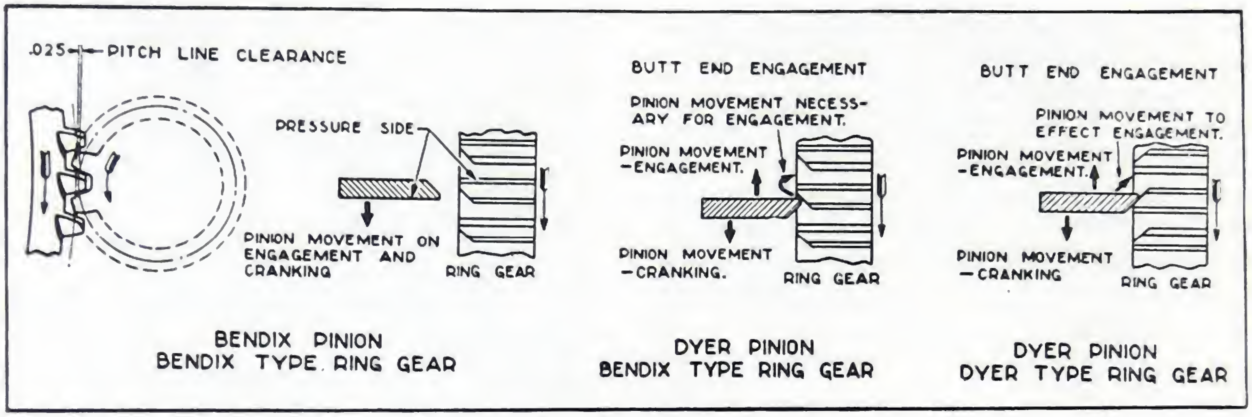


Fig. 11-6. Action of Dyer type pinion upon engagement with flywheel of different chamfer

upon cranking, but also tend to burr the teeth on either the pinion or flywheel depending upon which is the harder.

CHECKING AN IMPROPERLY OPERATING CRANKING MOTOR: 1. If the cranking motor does not develop rated torque and cranks the engine slowly or not at all, some indication of the source of trouble may be gathered by turning on the lights and attempting to crank.

A. If the lights go out as the cranking motor switch is closed, it is probable that a poor connection exists at the battery terminals or elsewhere in the circuit.

B. If the lights dim considerably, but still burn, it is likely that the battery is run down. Or, possibly there is some mechanical trouble either in the cranking motor or in the engine which makes it difficult for cranking to take place and an excessively high current drain on the battery consequently results.

C. If the lights do not dim, it indicates that there is no current flowing to the cranking motor, due either to the cranking motor or the cranking motor switch being open.

2. The preceding checks give only an approximate idea of the source of trouble so that in an emergency it might be possible to effect a temporary repair which would bring in the vehicle. To make a systematic analysis of the cranking motor system, the first step would be to check the battery specific gravity. Then the battery connections and cables should be checked, along with the cranking motor switch.

3. If all these are in order, remove the cover band and inspect the brushes and commutator. The brushes should form good contact with the commutator and the commutator must be reasonably clean and smooth. If it is not, it should be cleaned or turned down in a lathe. If there are burned bars on the commutator, it may indicate open circuited armature coils which will prevent proper cranking.

4. If leads have been thrown out of the armature slots, the indication is that the overrunning clutch caused the armature to be spun at an excessive speed due either to a defective clutch or to the fact that the operator of the vehicle was not starting the engine in the proper manner. If the operator opens the throttle too wide on initial starting, or if he keeps the starter pedal depressed for too long after the starting has been accomplished, the overrunning clutch may overheat and partially bind so that the armature is spun at excessive speeds. In addition to ruining the armature, the overrunning clutch also will be ruined by such abuse. Evidences of excessive overrunning of the clutch are failing of the bearings, depositing of bearing material on the armature shaft, and a smooth face in the collar on the side closest to the pinion.

5. Tight, dirty or worn bearings, bent shaft or loose pole shoe screws which allow the armature to drag will reduce armature speed or prevent the armature from turning.

6. If the brushes, brush spring tension, commutator, etc., all appear in good condition, it will be necessary to remove the cranking motor for further test.

GROUND CONNECTIONS OF THE STARTING MOTORS: In cases where the recom-

mended two-wire system is not used on the starting motor circuit, the ground wire should go directly from the positive terminal to the steel frame members and be grounded as shown in Fig. 11-2. The starter mounting surface should not be used for the ground circuit since the pads on the flywheel housing must carry this current to the frame and they may have paint or other highly resistant material on them.

Generator

The generator is a machine which converts mechanical energy into electrical energy and it has the job of supplying current for lights, and other electrical equipment, and keeping the battery in a charged condition by replacing in the battery the energy consumed by the cranking motor in starting.

TYPES: 1. Generators may be divided into two categories, according to their fundamental design: third brush and shunt. Third brush generators are used on applications where the current demands are small and the operation is more or less constant speed. The shunt generator gives improved low speed performance and it does not taper off at high speed as does the third brush unit.

2. The shunt generator requires some form of external current regulation, and the usual application incorporates a current regulator, voltage regulator and cut-off relay which operates together to provide control of the generator under all conditions of operation.

CLEANING: Clean the generator thoroughly of all grease and dust. Do not clean armature and field in a degreasing tank as this damages the insulation.

COMMUTATOR: 1. If the commutator is dirty, it may be cleaned with a strip of No. 00 sandpaper held against it with a piece of soft wood while the generator is operated. Blow out dust. NEVER USE EMERY CLOTH since emery may embed and wear the brushes rapidly.

2. If the commutator is rough, out of round, or has high mica, it must be turned down in a lathe and the mica undercut.

LUBRICATION: 1. The oil reservoir in the commutator end of the generator should be kept filled with light engine oil to the overflow hole. This usually requires the addition of 8-10 drops of oil every 1,000 miles.

2. Generators with grease cups should have the grease cups turned down one turn. Keep grease cups filled with medium cup grease. Do not lubricate excessively since this might allow oil or grease to get on the commutator where it would gum and burn and reduce generator output.

CONNECTIONS: 1. Check the connections and wiring in the generator-to-regulator-to-battery circuit. Check the pulley nut to be sure it is tight.

2. Make sure the mounting bolts are tight.

3. All generator installations should be checked carefully to make sure that they are properly grounded to the engine block. The generator mounting pads and mounting surfaces of the bracket and generator frame should be free of paint, oils, greases or any material resistant to electric current. To further complete the ground circuit, the engine should be grounded to the same frame member used to ground the battery, by means of a separate metal strap as shown in Fig. 11-2. This procedure must be followed on third-brush-type generators which have only one terminal, and on other generators having only one armature terminal, since the positive brushes on these generators are grounded to the generator frames.

CHECKING AND ADJUSTING OUTPUT: 1. The output of the shunt generator is dependent upon the setting of the current regulator.

2. The maximum output of third brush generators is dependent upon the position of the third brush. The third brush on many applications is fixed and cannot be adjusted, but the output on other third brush generators may be adjusted by moving the third brush in the direction of armature rotation to increase the output and in the opposite direction to lower the output. Third brush generator output should be checked and adjusted at the voltage specified since the generator output increases with voltage.

3. Normally, if the generator is checked with an accurate ammeter and a fully charged battery is in the circuit, the proper voltage will be de-

veloped. NEVER SET OUTPUT ABOVE SPECIFIED SETTING AS THIS WILL RESULT IN GENERATOR FAILURE.

CHECKING INOPERATIVE GENERATOR: If the generator is not performing according to specifications, and the tests outlined in the section on REGULATORS have disclosed that the generator is definitely at fault, it may be checked as follows to determine location of trouble in the generator.

No Output: When no output can be obtained from the generator, remove the cover band and check for sticking brushes, gummed or burned commutator or other causes of poor contact between commutator and brushes. If the cause of trouble is not readily apparent, remove the generator from the engine and send to generator service station for further tests and repairs.

Excessive Generator Output: Excessive generator output is usually due to either (a) a grounded field circuit or (b) a shorted field. Check the terminal insulation and if trouble can not be corrected there, send the generator to a service station.

Unsteady or Low Output: This condition may result in any generator from:

1. Sticking brushes, low brush spring tension, or other condition which prevents good contact between brushes and commutator.

2. Commutator which is rough, out of round, dirty, or burned. Dirt in the slots or high mica also cause low or unsteady output. With these conditions, the commutator should be turned down in a lathe and the mica undercut. Burned bars, of course, indicate an open circuit armature, and the corrections outlined above should be made.

Noisy Generator: This condition may be caused by loose mounting, or drive coupling. Worn or dirty bearings may also cause noise. Brushes improperly seated may cause noise which can be eliminated by properly seating them with a brush seating stone. A bent brush holder may cause noise and requires replacement since it is difficult to properly realign a holder.

POLARIZING GENERATOR: 1. After the generator is reinstalled on the engine, or at any time that generator or regulator tests have been made, the generator must be REPOLARIZED to make sure that it has the correct polarity with respect to the system. This must be done BEFORE THE ENGINE IS STARTED.

2. Different procedures of polarizing the generator must be used, depending on the type regulator on the application. BE SURE TO ALWAYS DETERMINE WHICH REGULATOR IS USED SO THE CORRECT PROCEDURE WILL BE FOLLOWED.

To Polarize Leece-Neville Generators: Connect a jumper lead momentarily between "G-" and "B-" connections on the reguator. This will allow a momentary surge of current from battery through generator to correctly polarize the generator.

To Polarize Delco-Remy Generators Using "1118200" and "1118300" Series Regulators: 1. The Delco-Remy "1118200" and "1118300" series regulators include all Delco-Remy regulators designated by 7 digits, the first 5 of which are "11182" or "11183".

2. Connect a jumper lead momentarily between the armature (or "GEN") and battery ("BAT") terminals of the regulator. This allows a momentary surge of current to flow through the generator from the battery to correctly polarize the generator.

To Polarize Delco-Remy Generators Using "5000", "1118400" and "1118500" Series Regulators: 1. Delco-Remy 5642, 1118469, 1118514 etc. regulators are included in this group.

2. Disconnect the "F" terminal lead from the generator, and then make a momentary connection with a jumper lead between this terminal and the insulated battery terminal. (On insulated systems, connect momentarily from generator "F" terminal to each battery terminal, "F" terminal lead disconnected from the generator. Current will flow through the generator field windings from one battery terminal only.) This allows a flash of current to flow through the generator field windings which correctly polarizes the generator.

To Polarize Delco-Remy 32 Volt, 15 Amp. Generators Using "1118540" and "1118595" Regulators: 1. Use same procedure as the 1118200 and 1118300 series.

CAUTION: NEVER OPERATE THE GENERATOR WITH THE FIELD CIRCUITS CONNECTED AND THE "A" TERMINAL LEAD DISCONNECTED (OPEN CIRCUIT OPERATION) SINCE THIS WOULD ALLOW A HIGH VOLTAGE TO BUILD UP WITHIN THE GENERATOR WHICH WOULD DAMAGE THE FIELDS AND ARMATURE.

Regulator Controls

Three separate magnetic switches must be used with the shunt generator in order to provide complete control at all times. These are (1) the cutout relay, (2) the voltage regulator and (3) the current regulator.

CUT-OUT RELAY: 1. The cut-out relay closes the circuit between the generator and the battery when the generator voltage has built up to a value sufficient to force a charge into the battery.

2. The cut-out relay opens the circuit when the generator slows or stops and current begins to flow back from the battery into the generator.

3. The basic wiring diagram for a one-terminal, third-brush current controlled generator used with a cut-out relay is shown in Fig. 11-7. Equipment which requires low generator output, such as shovels and power units, will sometimes have this type of generator and cut-out relay.

4. This type of equipment will give satisfactory service provided the G+ B+ terminal of the relay is properly grounded to the same frame member used to ground the battery, as shown in Fig. 11-7, and provided the generator is used only for battery charging.

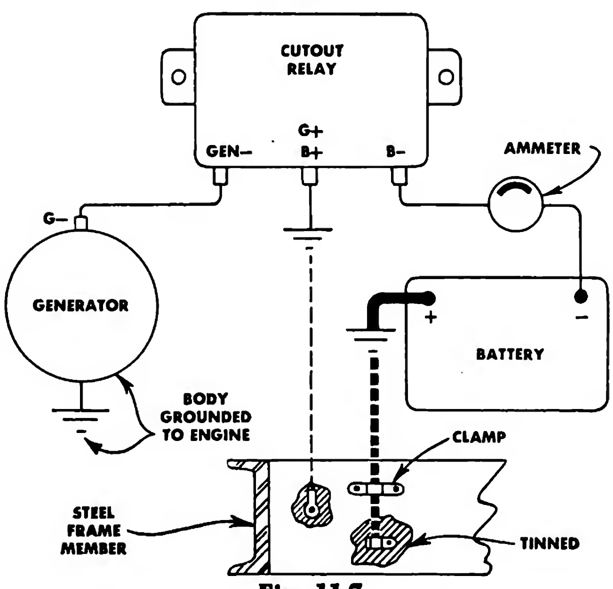


Fig. 11-7

VOLTAGE REGULATOR: 1. The voltage regulator prevents the line voltage from exceeding a predetermined value and thus protects the battery and other electrical units in the system from high voltage.

2. One characteristic of batteries is that as either the specific gravity or the charging rate increases, other conditions being the same, the battery terminal voltage increases. If the terminal voltage is held constant as the battery comes up to charge (specific gravity increases), the charging rate will be reduced. The voltage regulator performs this job of holding the voltage constant and it consequently protects the electrical system from high voltage and the battery from overcharge.

CURRENT REGULATOR: 1. The current regulator limits the generator output to a safe value. It is, in effect, a current limiting device which operates when the generator output has increased to its safe maximum and prevents the generator from exceeding this value.

REGULATOR OPERATING VOLTAGES: 1. Regulators are factory adjusted according to the system in which they work.

2. For use in nominal 12 volt systems the regulator is adjusted to properly charge, under normal conditions, 6 cell batteries.

3. Because either 15 cell or 16 cell batteries may be used in nominal 32 volt systems, particular attention must be given to the application of regulators in a 32 volt system. These regulators are stamped "15 cell" or "16 cell" to indi-

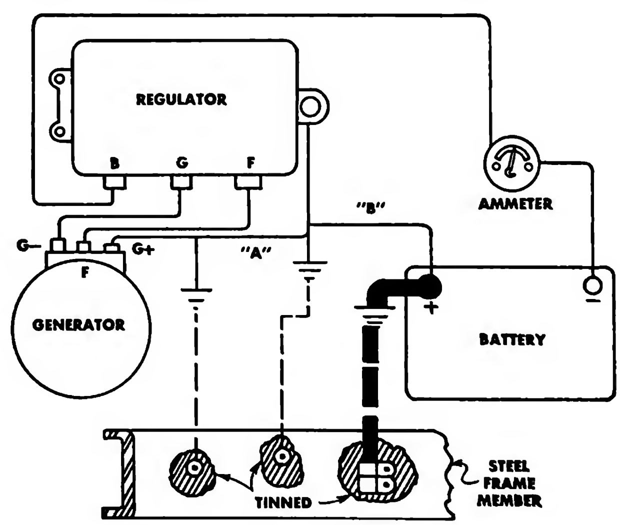


Fig. 11-8

cate that they have been factory adjusted for use with a battery having the specified number of cells. To use a regulator stamped "15 cell" with a 16 cell battery would result in a weak-charged battery and, conversely, a "16 cell" regulator would cause overcharging of a 15 cell battery.

Current and Voltage Regulator Connections: The basic diagram for Leece-Neville equipment is shown in Fig. 11-8 and is now supplied with the so-called "universal" regulator. For satisfactory operation, the steel base of the regulator must be grounded as shown because these regulators have small doughnut-type rubber shock mounts bonded to the base and depend entirely on this grounding strap and the capscrews to ground the unit.

Wire shown as "A" and "B" in Fig. 11-8 indicate the alternate connections necessary for the recommended two-wire system.

Some larger voltage regulation control units have cast aluminum bases and covers. These units are not grounded through their bases but by separate wires from insulated terminals. This would be indicated on the unit working diagram.

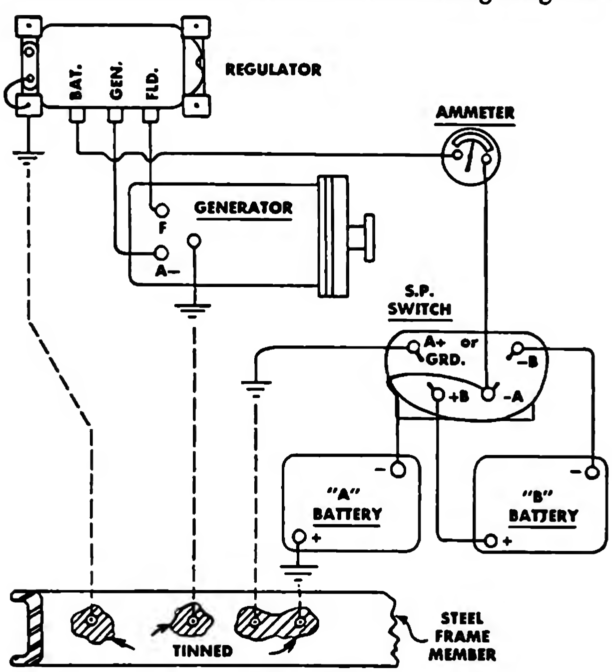


Fig. 11-9

Fig. 11-9 shows the charging connections of the 12-24 Volt Delco-Remy system as now supplied on production engines. For satisfactory operation of this system, the following points should be checked in addition to the proper grounding to a common steel frame member as indicated:

1. The flexible ground lead should be carefully installed since, without this, the regulator base is insulated from its mounting surface by the rubber shock mounts. This is particularly true on old regulators to which shock mounts have been added for improved performance.

2. These generators should have a ground wire connected to the screw located close to the terminals.

3. The series-parallel switch shown has internal circuit breakers between A— and B— terminals and also between the A+ and B+ terminals. Earlier design switches had a spring contact arrangement under the B— and A+ terminals. Trouble has been experienced on some installations because the wire terminals have been placed between the *lower* nut and the switch body. This caused an open circuit and

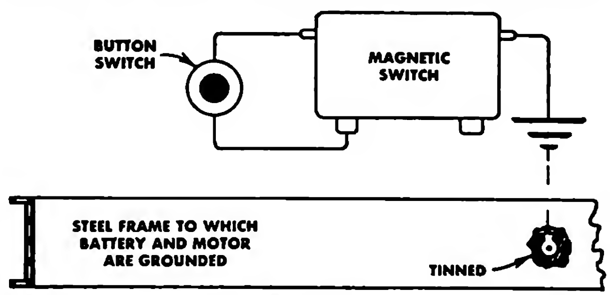


Fig. 11-10

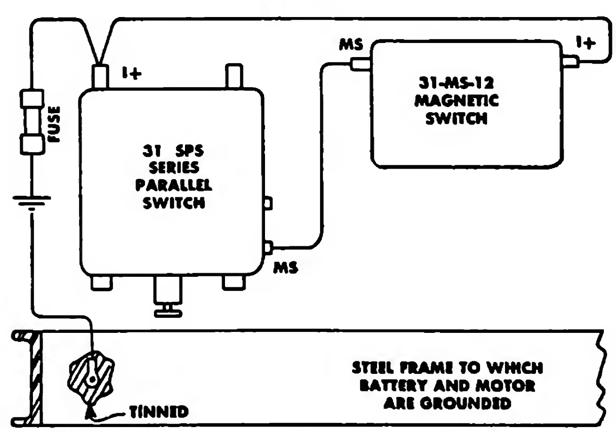


Fig. 11-11

prevented the "B" battery from being charged.

Twenty-four volt systems using two-wire circuits should have the positive side grounded to a frame member since it is possible for

operating personnel to receive a shock during starting of supercharged engines when the cold starting coil is turned "on". See Figs. 11-10 and 11-11.

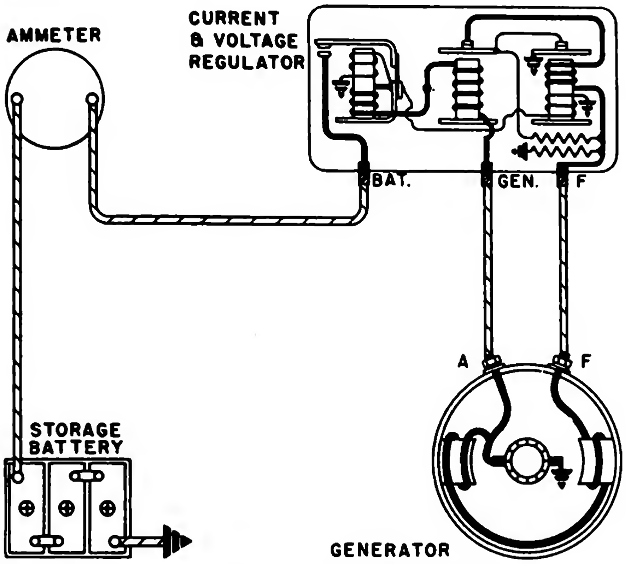


Fig. 11-12. Current and voltage regulator wiring circuit. (Standard type)

GENERATOR CUT-IN: It is advisable to check the cut-in point of the generator regulator at idling speed. On engines equipped with the low cut-in-type generator regulator, the ammeter will indicate some value of charging when the electric load is off. On other generator regulator systems, the ammeter will read "0". In either case, the ammeter should remain steady.

Erratic movement of the ammeter indicates that the regulator relay is cutting in and out frequently and this will cause an electric arc at these connections. If arcing continues, the points will eventually weld together which will leave the circuit closed at all times. This will cause an overcharge into the battery during operation and a discharge through the generator when the engine is stopped, and this will eventually burn up the generator and regulator. To overcome this condition, it will be necessary to increase the engine idling speed until the ammeter remains almost constant. Ammeter movement may indicate a loose connection.

STANDARD WIRING DIAGRAMS

DIAGRAM NO.	PAGE	DESCRIPTION	ENGINES SPECIFIED FOR
41738	11-14	24 Volt, 250 Watt; 32 Volt, 350 and 750 Watt Delco-Remy Insulated System with Heavy Duty Regulators and Push Button starting.	H and NH Series
42591-1	11-15	12-24 Volt, 8 Amp. and 50 Amp. Delco-Remy Pedal operated Series Parallel System.	H and NH Series
42592-1	11-16	12-24 Volt, 8 Amp. and 50 Amp. Delco-Remy Solenoid operated Series Parallel System.	H and NH Series
42593	11-17	24 Volt, 20 Amp. (500 Watt) Delco-Remy System with Push Button Starting and Small Regulator.	H and NH Series
42593-2	11-18	24 Volt, 20 Amp. (500 Watt). Delco-Remy System with P. B. Starting, Small Regulator 43630 Spark Coil and 43631 Resistor.	H and NH Series
42594	11-19	30-32 Volt, 15 Amp. (500 Watt) Delco-Remy System with Push Button Starting, Bendix Starter, and Large Regulator.	H and NH Series
42594-2	11-20	30-32 Volt, 15 Amp. (500 Watt) Delco-Remy System with P. B. Starting, Bendix Starter, Large Regulator, 43630 Spark Coil and 43631 Resistor. Delco-Remy "A" Type Gen.-Reg. Circuit.	H and NH Series
42607	11-21	12-24 Volt, 60 Amp. (840 Watt) Leece-Neville Series Parallel Rectified Alternating Current Power System.	H and NH Series

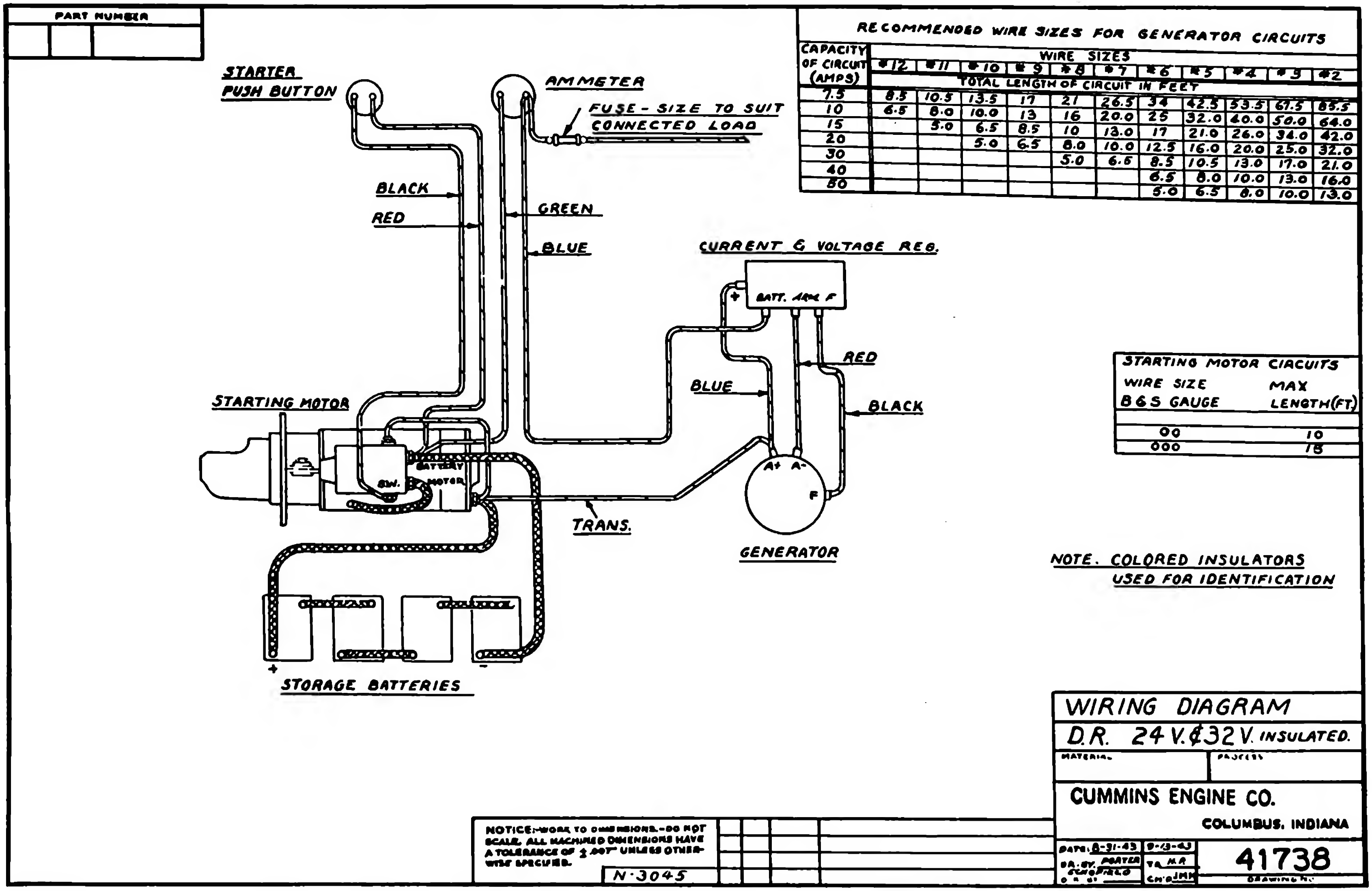
STANDARD WIRING DIAGRAMS

DIAGRAM NO.	PAGE	DESCRIPTION	ENGINES SPECIFIED FOR
42657	11-22	12-24 Volt, 60 Amp. (840 Watt) Leece-Neville and Delco-Remy Series (Parallel Rectified Alternating Current Power System.	H and NH Series
42713	11-23	12-24 Volt, 100 Amp. (1400 Watt) Leece-Neville Series Parallel Rectified Alternating Current Power System.	H and NH Series
42797	11-24	12-24 Volt, 250 to 700 Watt, 20 to 50 Amp., Leece-Neville System with Small, 3-Element, Regulator and P. B. Starting.	H and NH Series
43410-1	11-25	32 Volt, 50 Amp. (1750 Watt) Delco-Remy Heavy Duty System with Carbon Pile Regulator, P. B. Starting, Bendix Starter, 43630 Spark Coil and 43631 Resistor.	H and NH Series
43715	11-26	32 Volt, 50 Amp. (1750 Watt) Leece-Neville Dual Generator Single Battery System with Paralleling Relay.	H, NH, and NHH Series
44113	11-27	24 Volt, 20 Amp. Delco-Remy System with Bendix Drive Starting Motor and Magnetic Switch.	H and NH Series
44140	11-28	32 Volt, 15 Amp. Delco-Remy System with Bendix Drive Starting Motor and Standard Duty Magnetic Switch. Delco-Remy "B" Type Gen.-Reg. Circuit.	H and NH Series
44236	11-29	32 Volt, 15 Amp. Delco-Remy System with Bendix Drive Starting Motor and Heavy Duty Magnetic Switch. Delco-Remy "B" Type Gen.-Reg. Circuit.	H and NH Series
61622	11-30	12-24 Volt, 120, 240, 375, 600 and 825 Watt Delco-Remy Series Parallel System, with Foot Pedal Starting.	H and L Series
62067	11-31	32 Volt, 350 Watt Leece-Neville Insulated System with Push Button Starting.	H and NH Series
62072	11-32	32 Volt, 1500 Watt Leece-Neville Insulated System with Push Button Starting.	H and NH Series
62581	11-33	12-24 Volt, 120, 240, 375, 600 and 825 Watt Delco-Remy Series Parallel System, with Push Button Starting.	H and NH Series
63099	11-34	32 Volt, 350, 750, and 1500 Watt Leece-Neville Insulated System with Two Stage Switch Starting.	L and NVH Series
63196-1	11-35	12 Volt, 250, 375, 600, 825 Watt Delco-Remy Grounded System with Push Button Starting.	A Series
63258	11-36	24 Volt, 250 Watt Leece-Neville Insulated System with Cut Out Relay and Push Button Starting.	H Series
64105	11-37	24 Volt, 250 and 400 Watt Leece-Neville Grounded System with Push Button Starting (Also 12 Volt 700 Watt).	A and H Series

STANDARD WIRING DIAGRAMS

DIAGRAM NO.	PAGE	DESCRIPTION	ENGINES SPECIFIED FOR
64106	11-38	12 and 24 Volt, 150 Watt Leece-Neville Grounded System with 3rd Brush Generator, Cut Out Relay & Push Button Starting.	A and H Series
64107	11-39	24 Volt, 650 Watt Leece-Neville Grounded System with Push Button Starting.	H Series
64463	11-40	12 Volt, 150 Watt Leece-Neville Ground System with Cut Out Relay and P. B. Starting.	A Series
67319	11-41	32 Volt, 350 and 750 Watt Leece-Neville Insulated System with Heavy Duty Regulator and P. B. Starting.	H and NH Series
67320	11-42	12-24 Volt, 500 and 700 Watt Leece-Neville Series Parallel System with Heavy Duty Regulator (+ Grounded.)	H and NH Series
68173	11-43	12 Volt, 250 to 500 Watt, 20 to 40 Amp. L. N. System with Small 3-Element Regulator and P. B. Starting.	A Series
68337	11-44	12 Volt, 100 Amp. (1400 Watt) Leece-Neville Rectified Alternating Current Power System.	A and JS Series
68791	11-45	12 Volt, 40 or 50 Amp. (560 or 700 Watt) Delco-Remy with standard three element regulator and P. B. starting.	JS Series

Fig. 11-13. 24 volt, 250 watt; 32 volt, 350 and 750 watts Delco-Remy Insulated System with Heavy Duty Regulators and Push Button Starting



RECOMMENDED WIRE SIZES FOR GENERATOR CIRCUITS

CAPACITY OF CIRCUIT (AMPS)	WIRE SIZES #12	#11	#10	#9	#8	#7	#6	#5	#4	#3	#2
	TOTAL LENGTH OF CIRCUIT IN FEET										
7.5	8.5	10.5	13.5	17	21	26.5	34	42.5	53.5	67.5	85.5
10	6.5	8.0	10.0	13	16	20.0	25	32.0	40.0	50.0	64.0
15		5.0	6.5	8.5	10	13.0	17	21.0	26.0	34.0	42.0
20			5.0	6.5	8.0	10.0	12.5	16.0	20.0	25.0	32.0
30					5.0	6.5	8.5	10.5	13.0	17.0	21.0
40							6.5	8.0	10.0	13.0	16.0
50							5.0	6.5	8.0	10.0	13.0

STARTING MOTOR CIRCUITS

WIRE SIZE B & S GAUGE	MAX LENGTH (FT.)
00	10
000	15

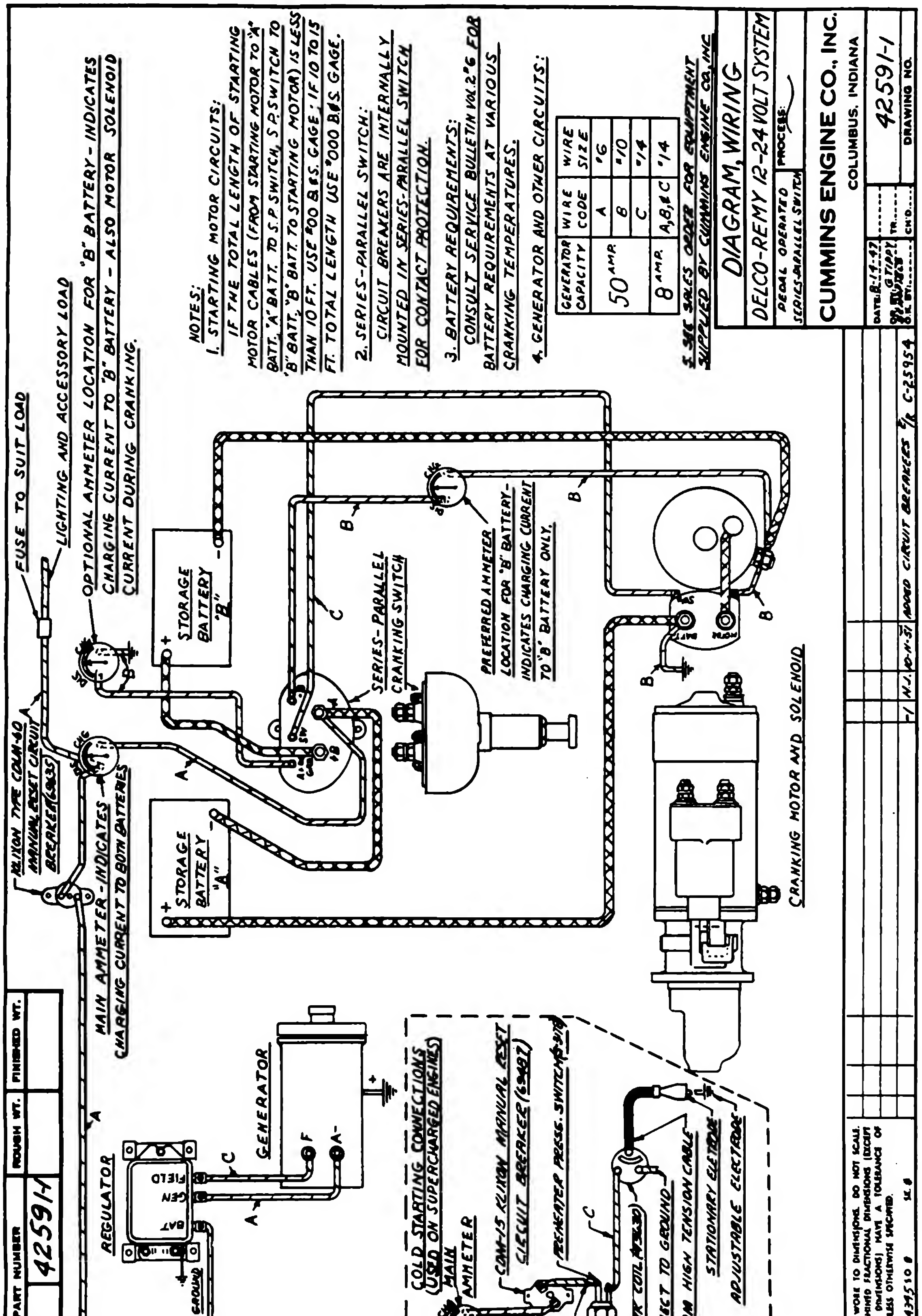
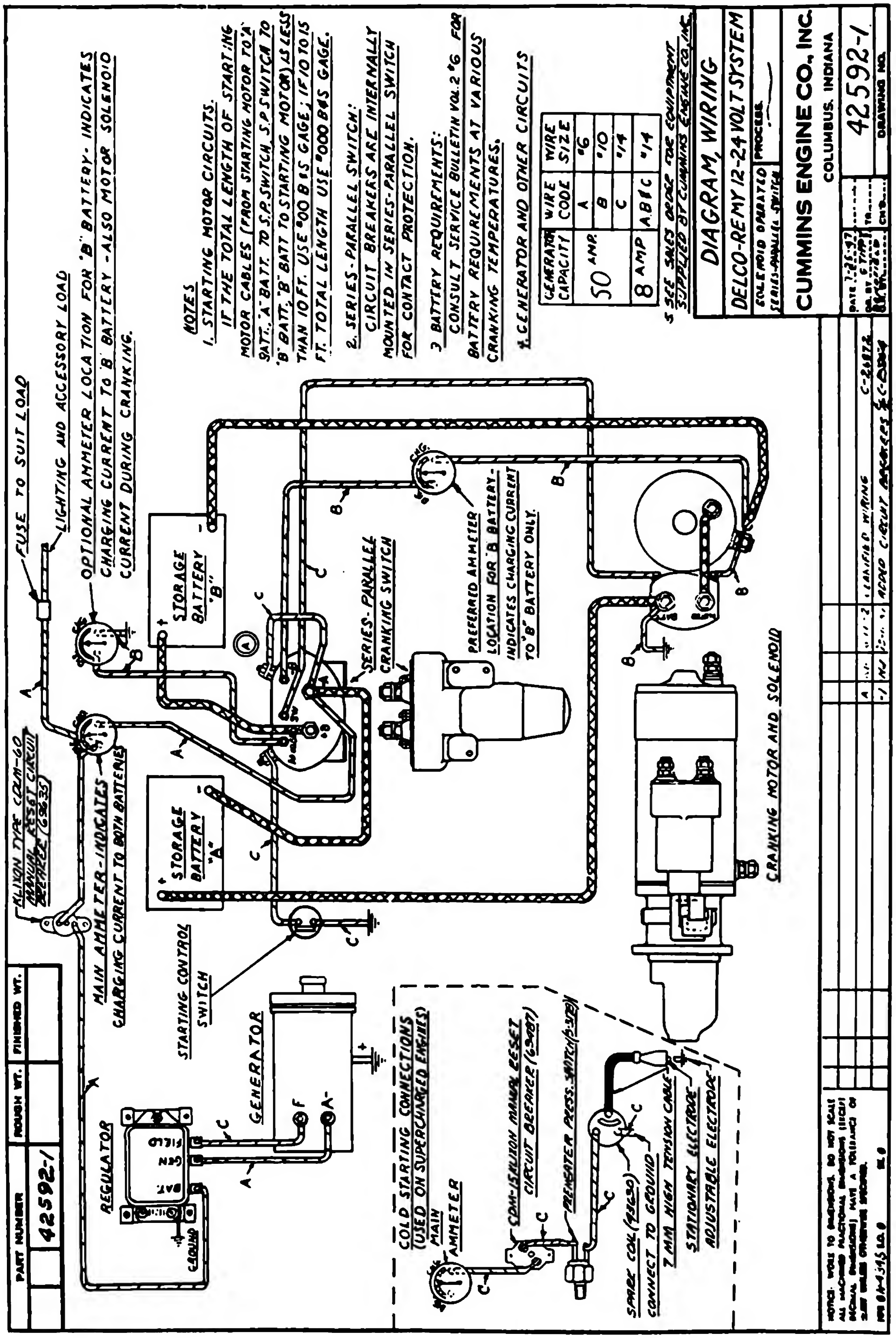


Fig. 11-14. 12-24 volt; 8 ampere and 50 ampere Delco-Remy Pedal Operated Series Parallel System

Fig. 11-15. 12-24 volt; 8 ampere and 50 ampere Delco-Remy Solenoid Operated Series Parallel System



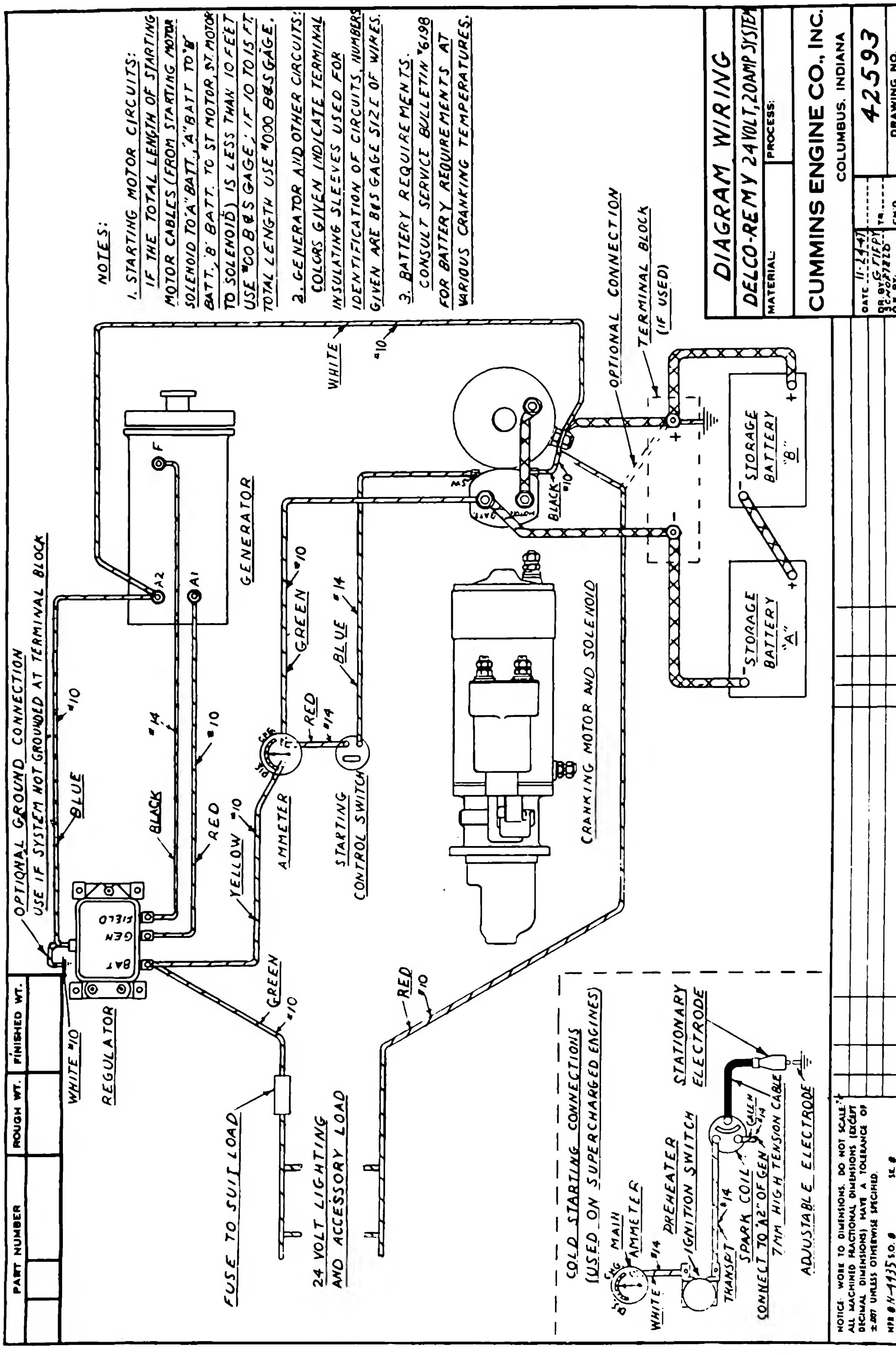
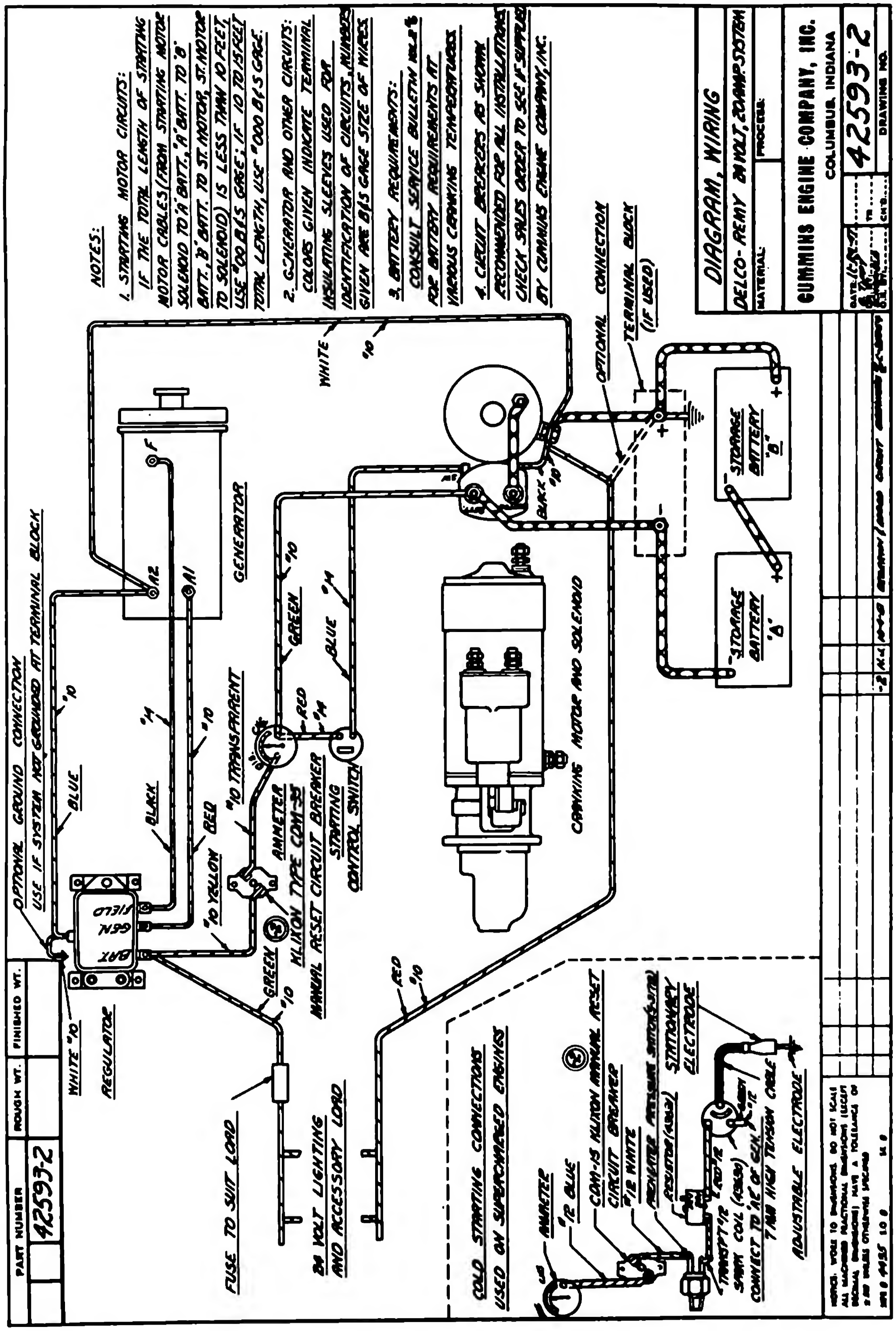


Fig. 11-16. 24 volt; 20 ampere (500 watt) Delco-Remy System with Push Button Starting and Small Regulator

Fig. 11-17. 24 volt; 20 amp. (500 watt) Delco-Remy with P. B. Starting, Small Regulator, 43630 Spark Coil and 43631 Resistor



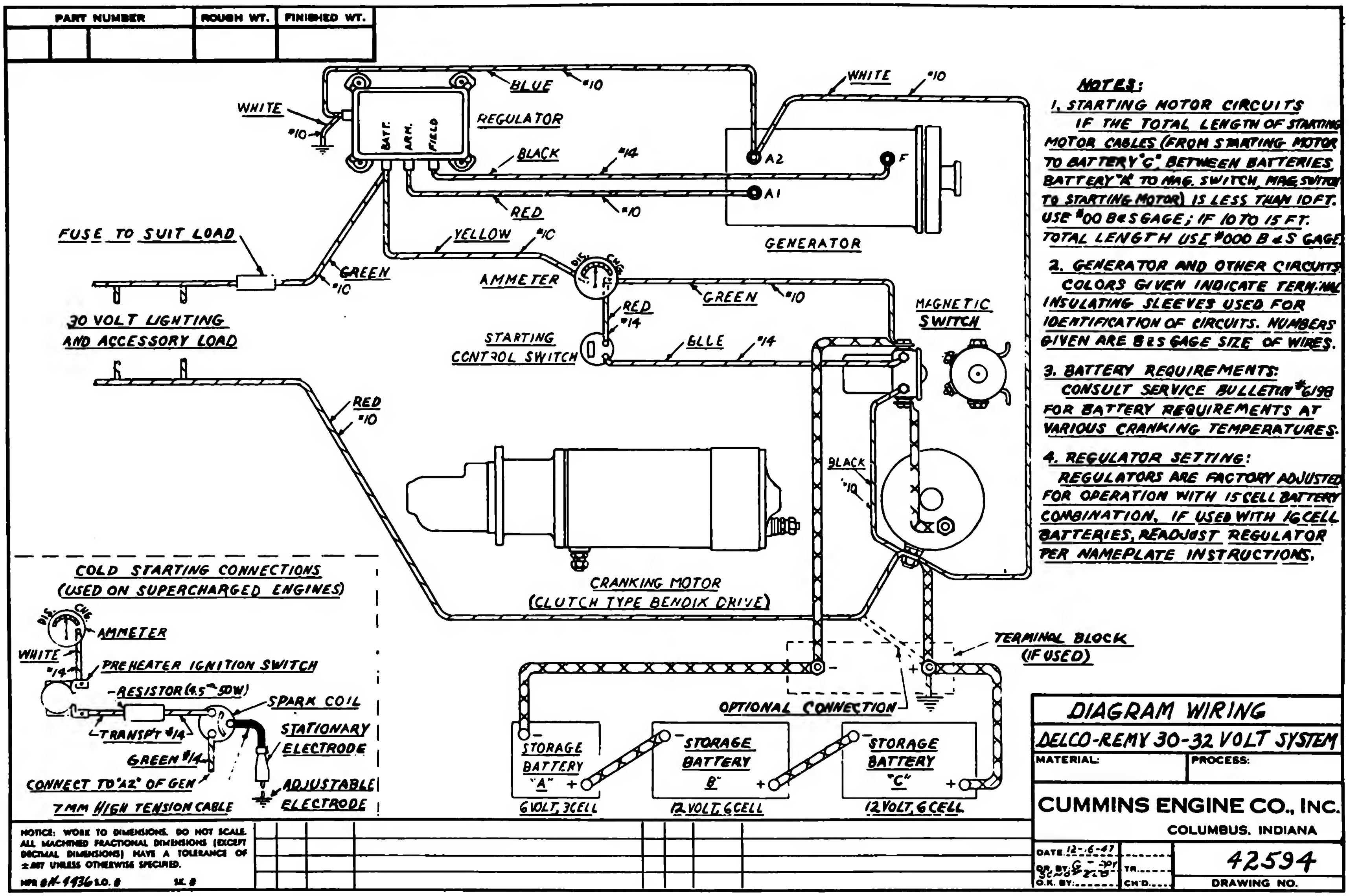


Fig. 11-18. 30-32 volt; 15 ampere; 500 watt Delco-Remy System with Push Button Starting, Bendix Starter and Large Regulator

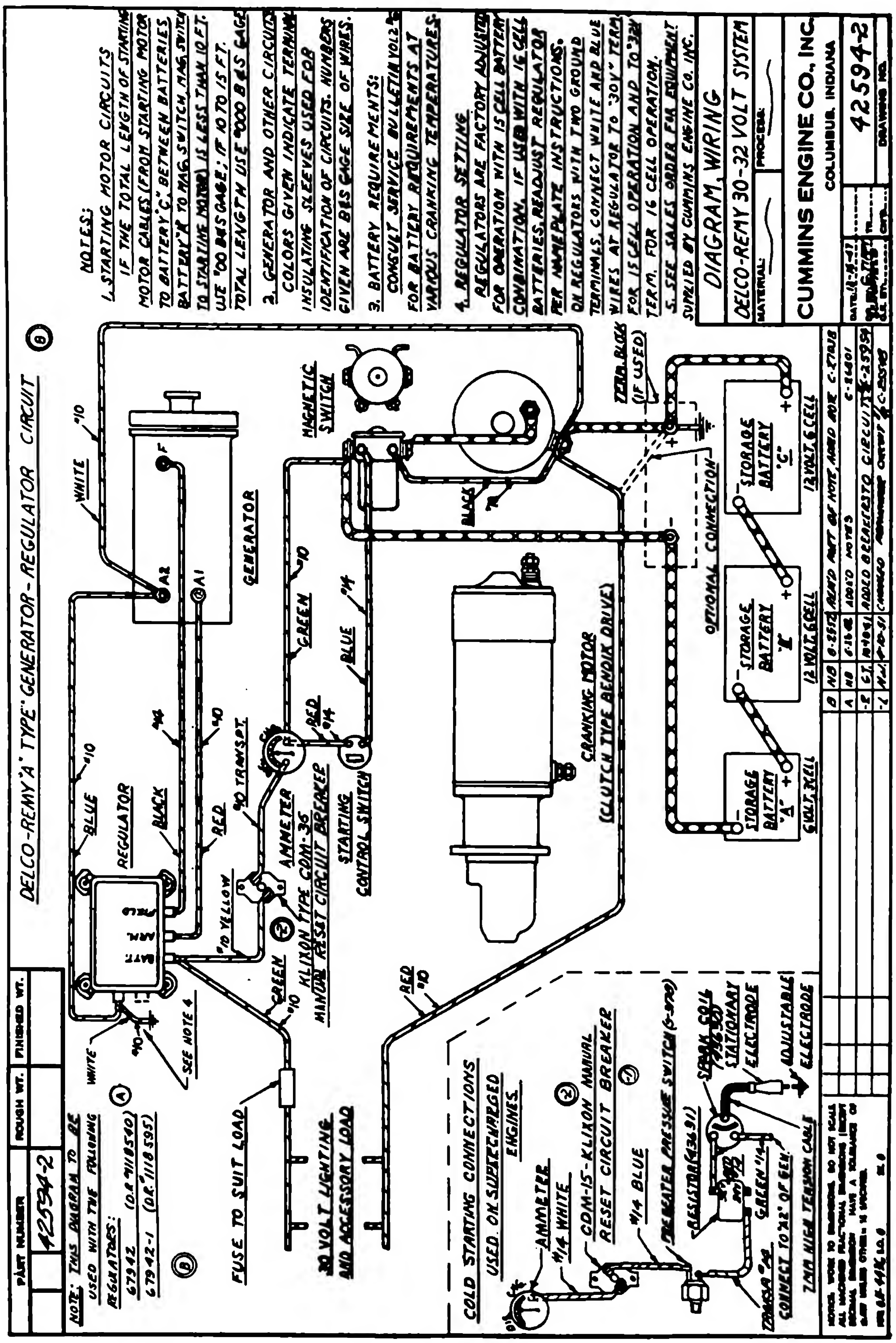


Fig. 11-19. 30-32 volt; 15 ampere (500 watt) Delco-Remy System with P. B. Starting, Bendix Starter, Large Regulator, 43630 Spark Coil and 43631 Resistor

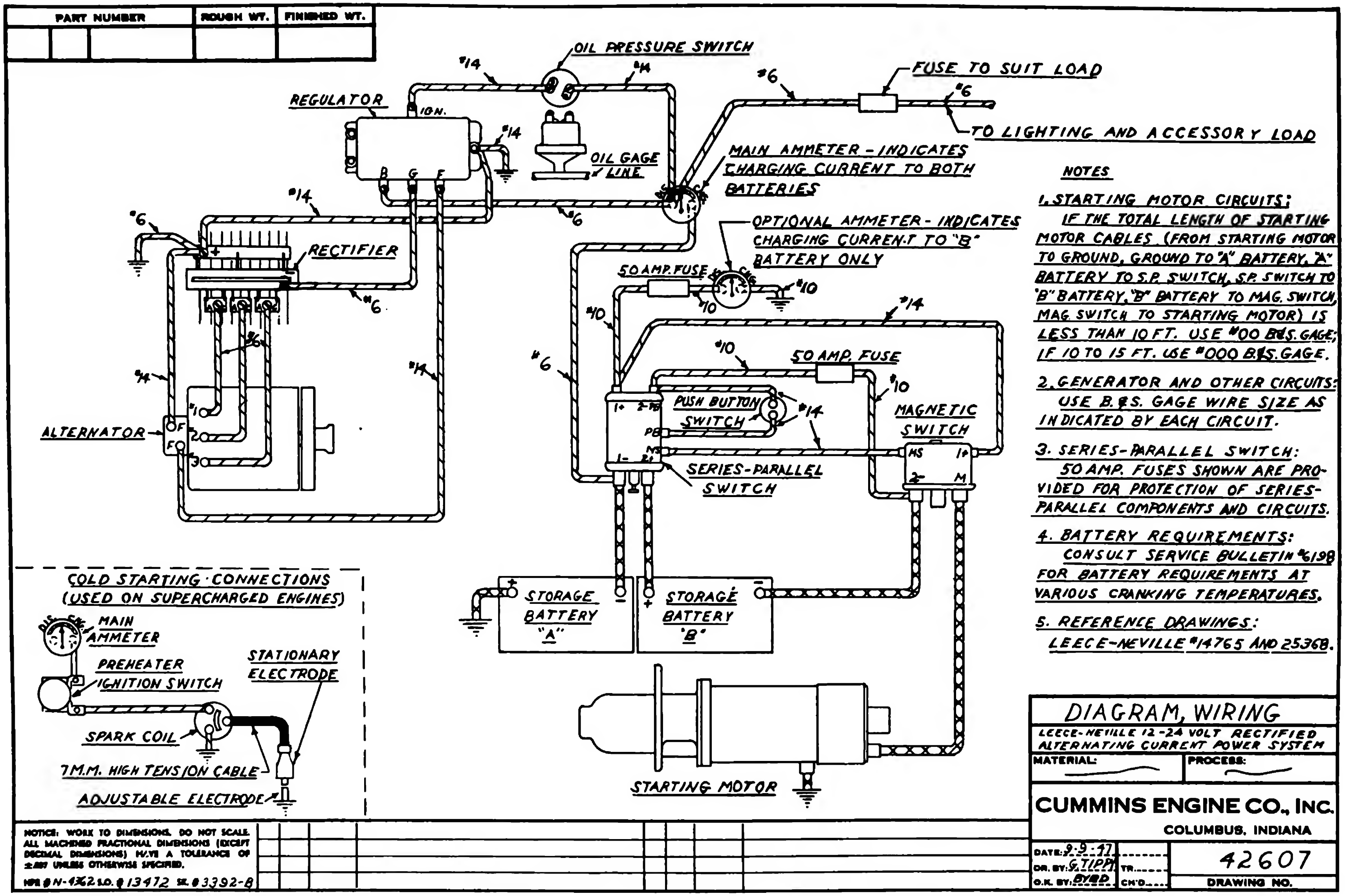
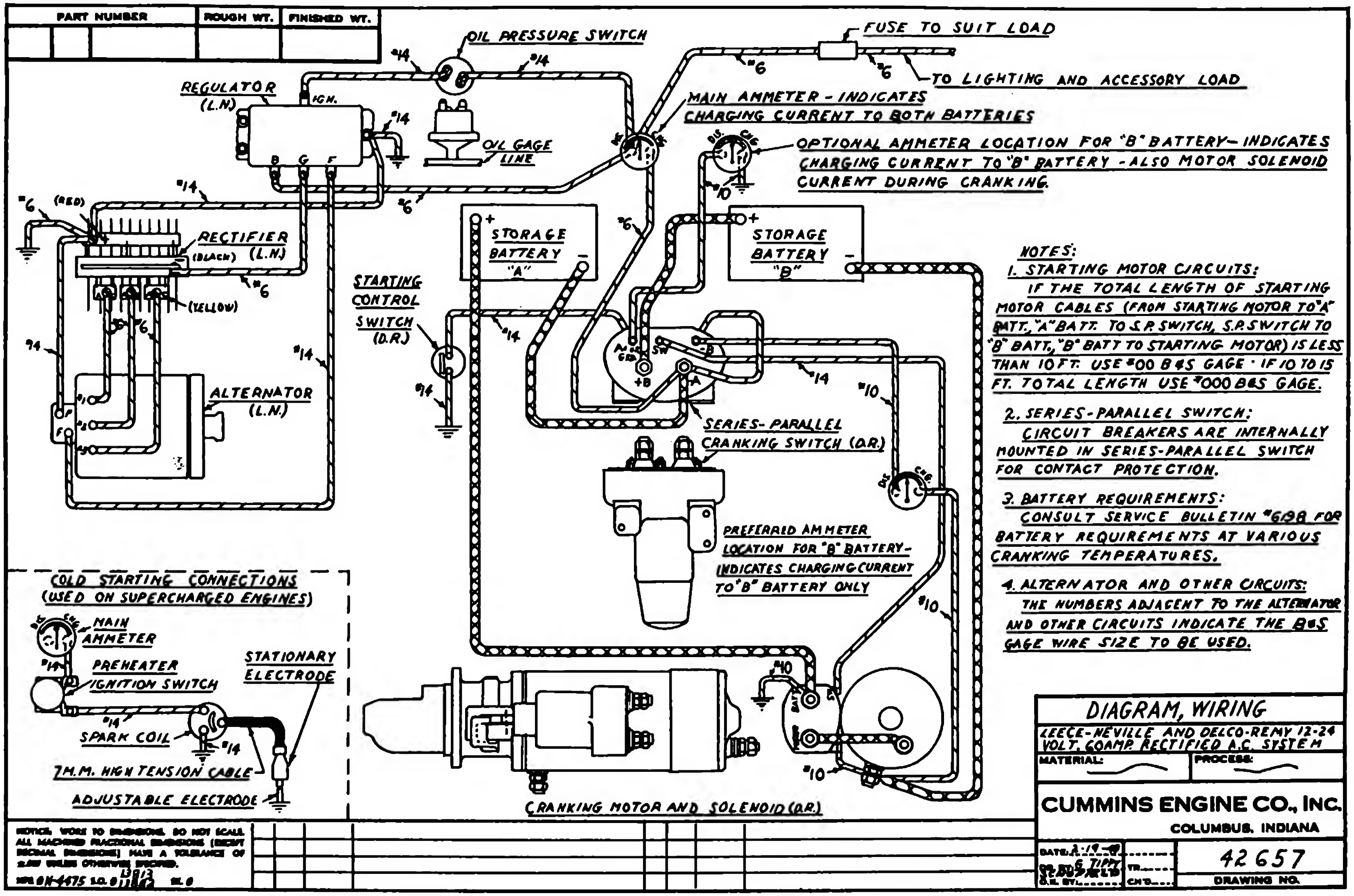


Fig. 11-20. 12-24 volt; 60 ampere; 840 watt Leece-Neville Series Parallel Rectified Alternating Current Power System

Fig. 11-21. 12-24 volt; 60 ampere; 840 watt Leece-Neville and Delco-Remy Series Parallel Rectified Alternating Current Power System



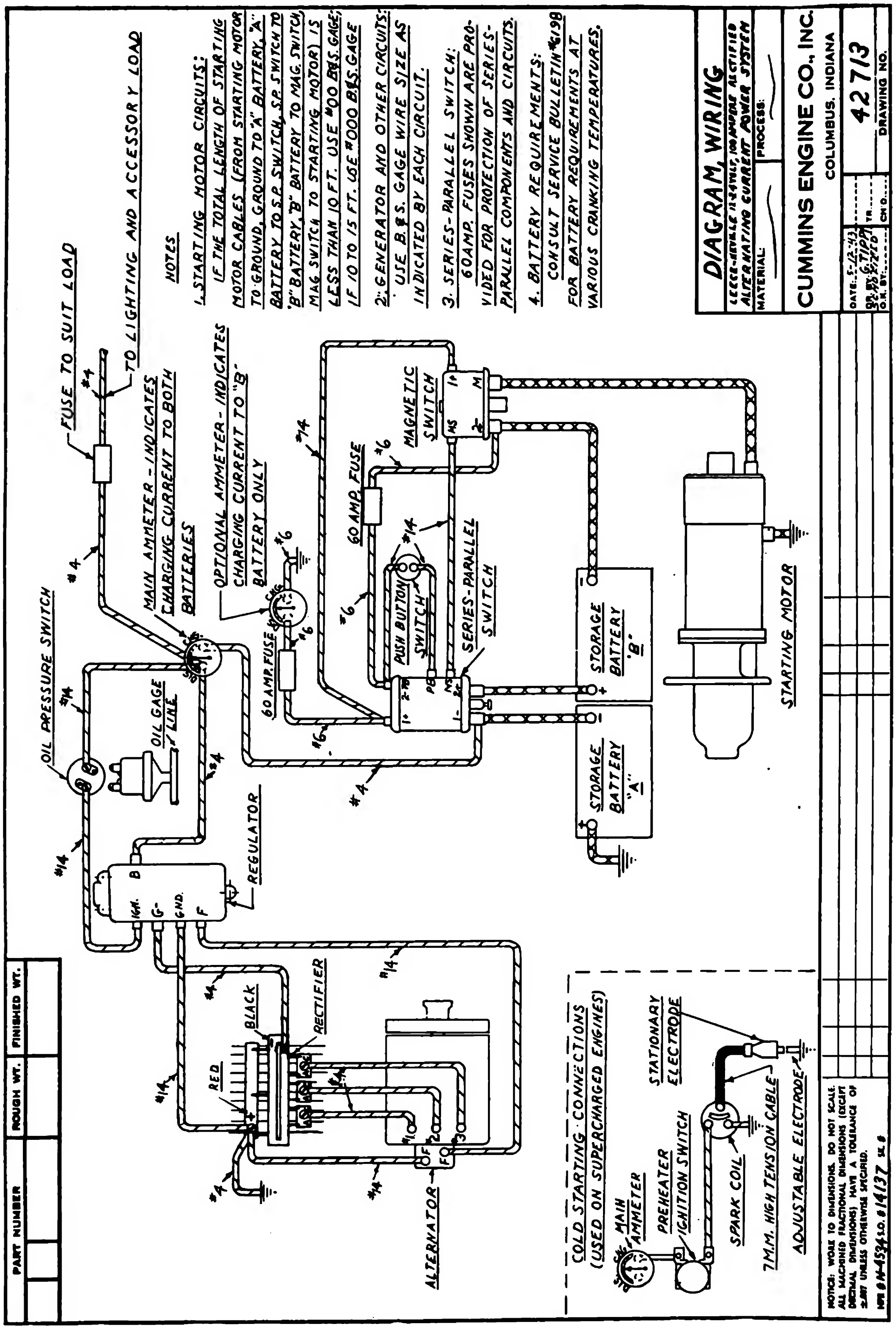
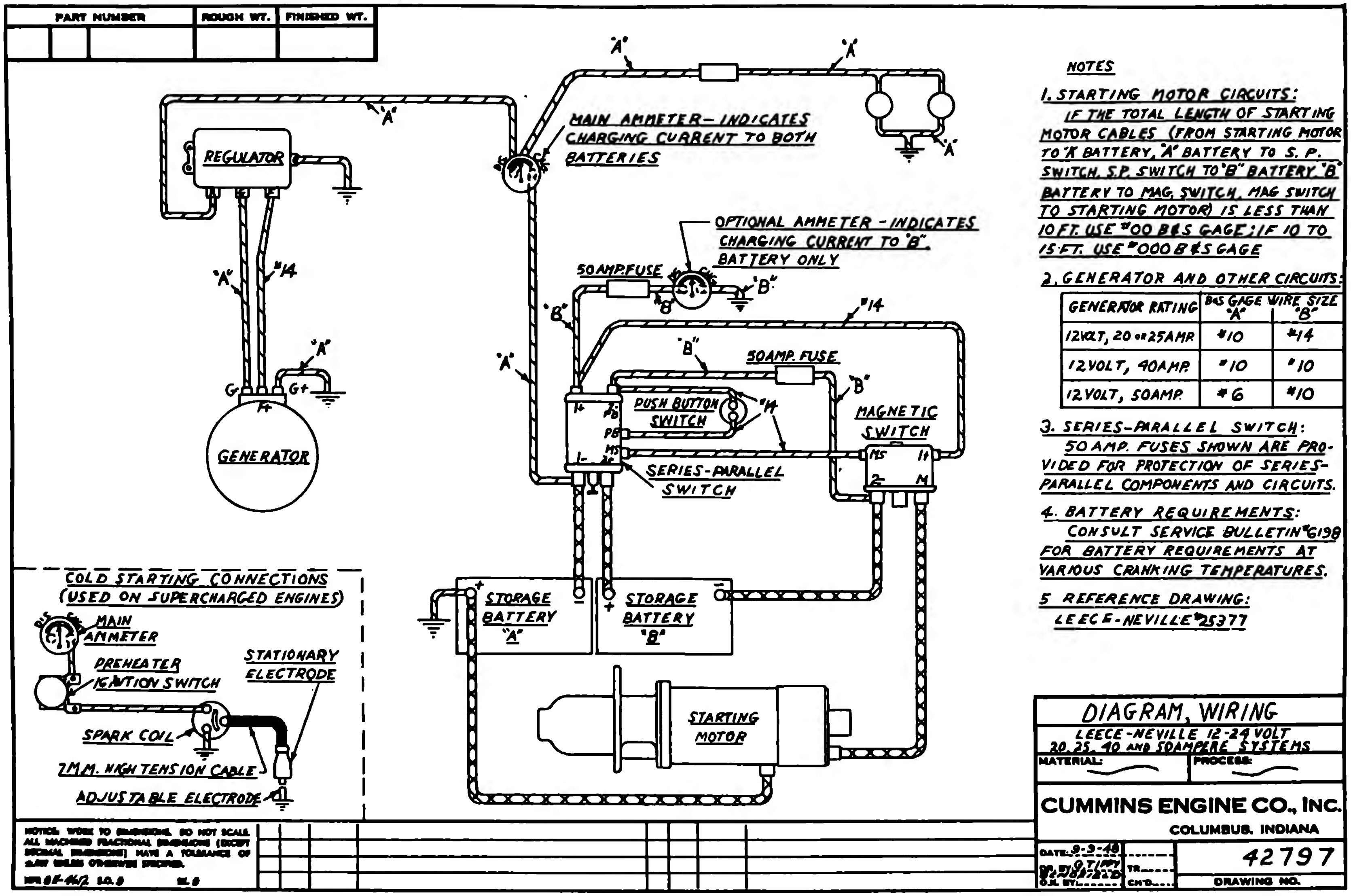


Fig. 11-22. 12-24 volt; 100 ampere; 1400 watt Leece-Neville Series Parallel Rectified Alternating Current Power System

Fig. 11-23. 12-24 volt; 20 to 50 ampere; 250 to 700 watt Leece-Neville System with Small 3-element Regulator and P. B. Starting



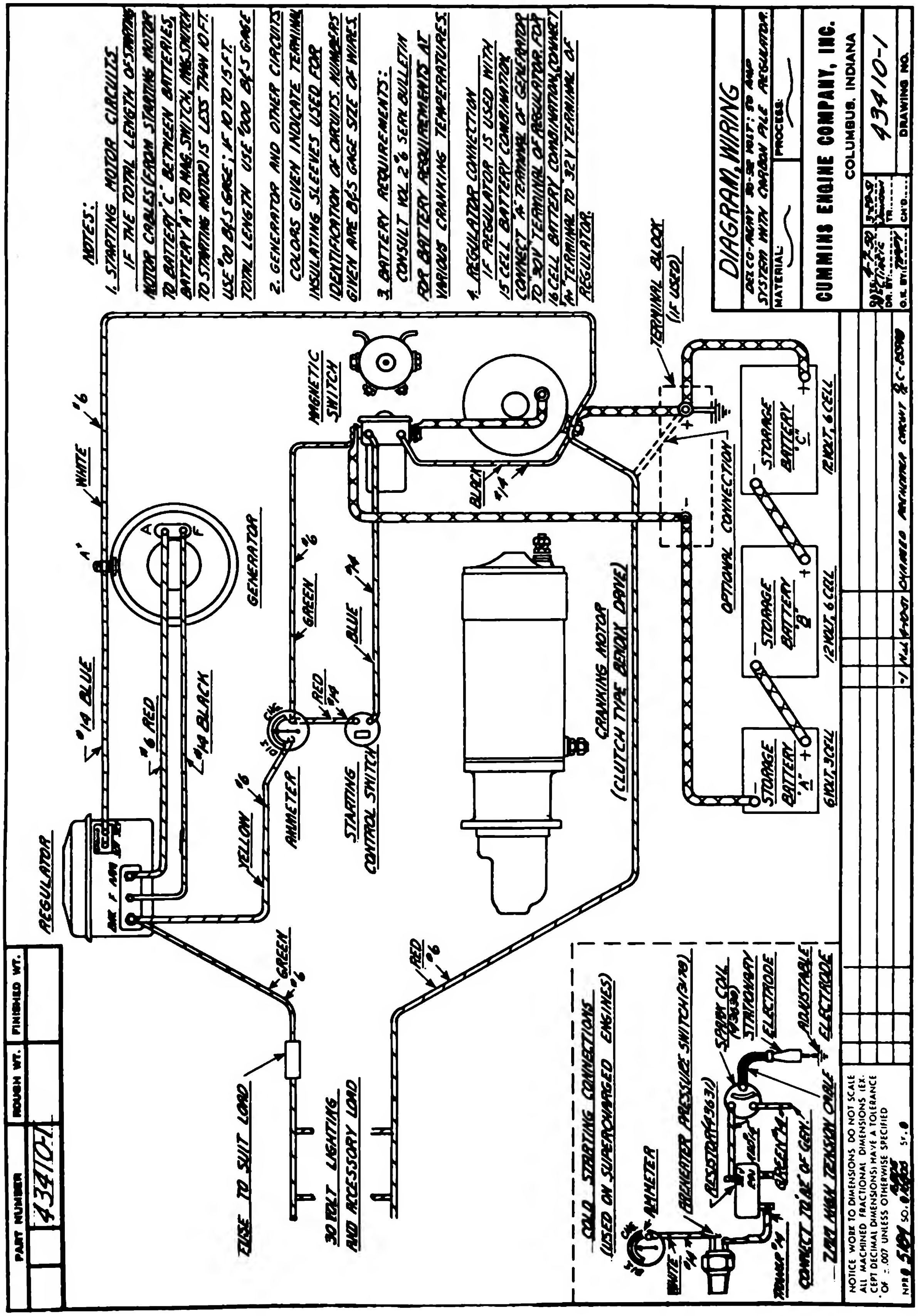


Fig. 11-24. 32 volt; 50 ampere; (1750 watt) Delco-Remy Heavy Duty System with Carbon Pile Regulator, P. B. Starting, Bendix Starter, 43630 Spark Coil and 43631 Resistor

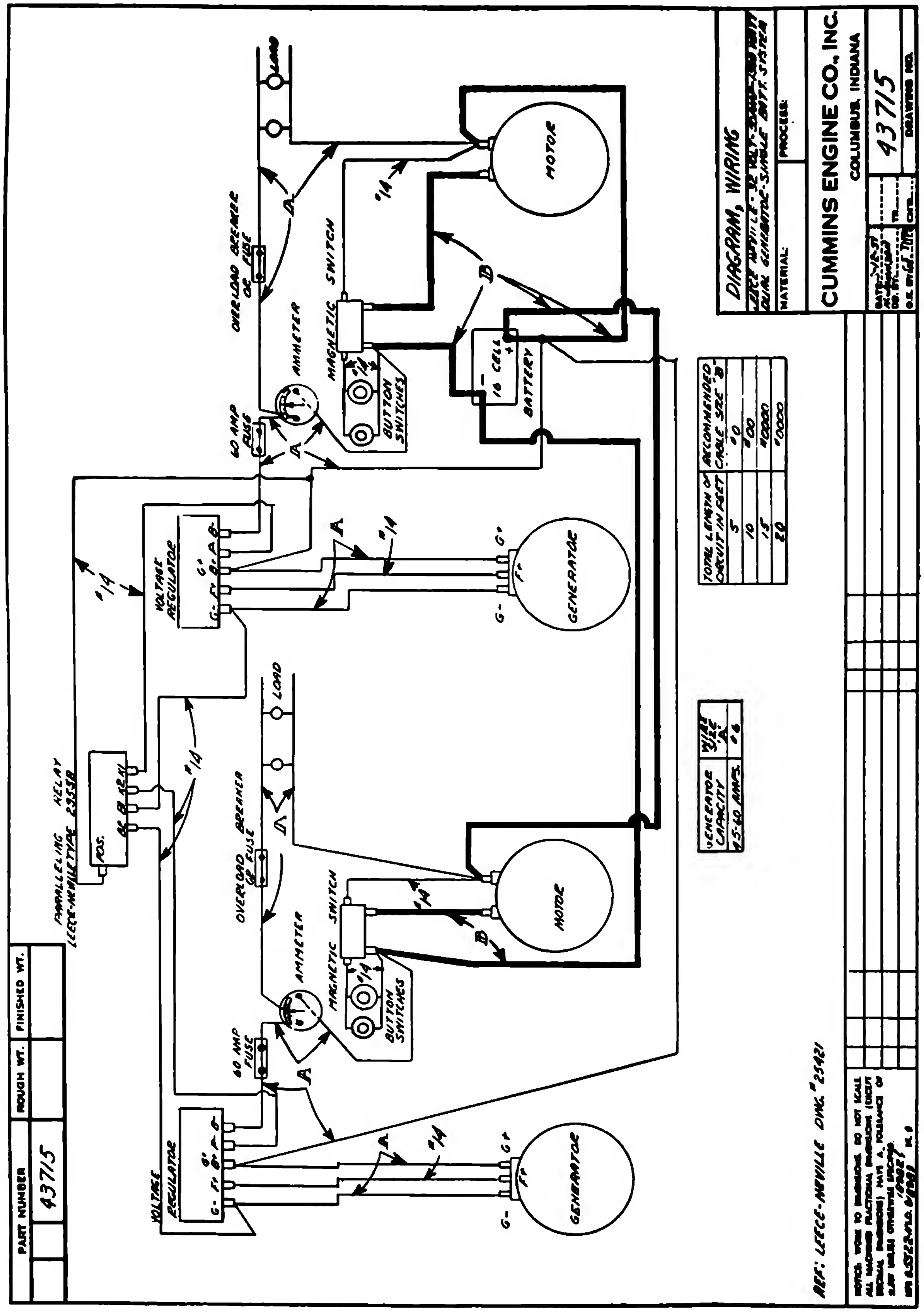


Fig. 11-25. 32 volt; 50 ampere (1750 watt) Leece-Neville Dual Generator, Single Battery System with Paralleling Relay

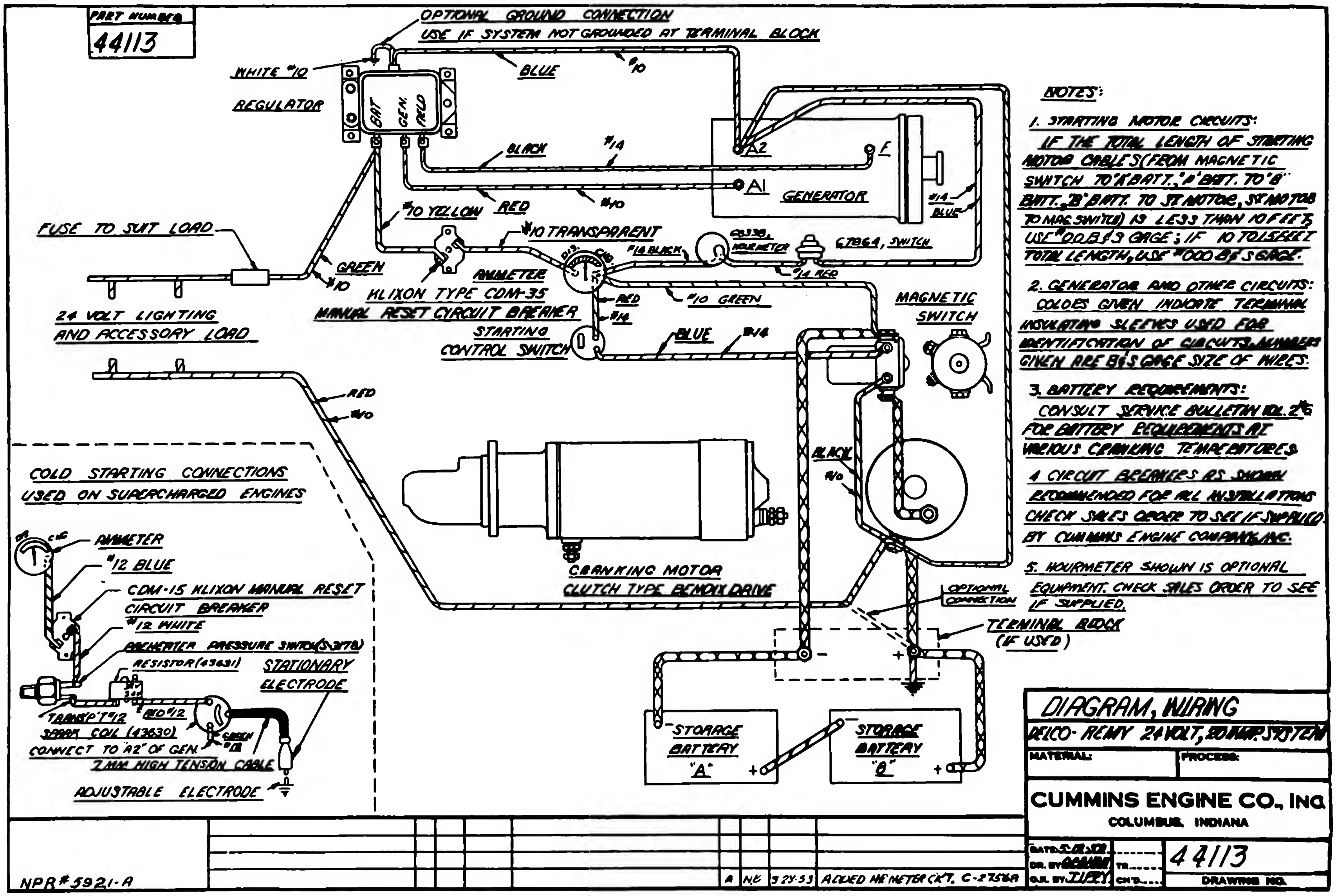


Fig. 11-26. 24 volt, 20 amp. Delco-Remy System with Bendix Drive starting motor and magnetic switch

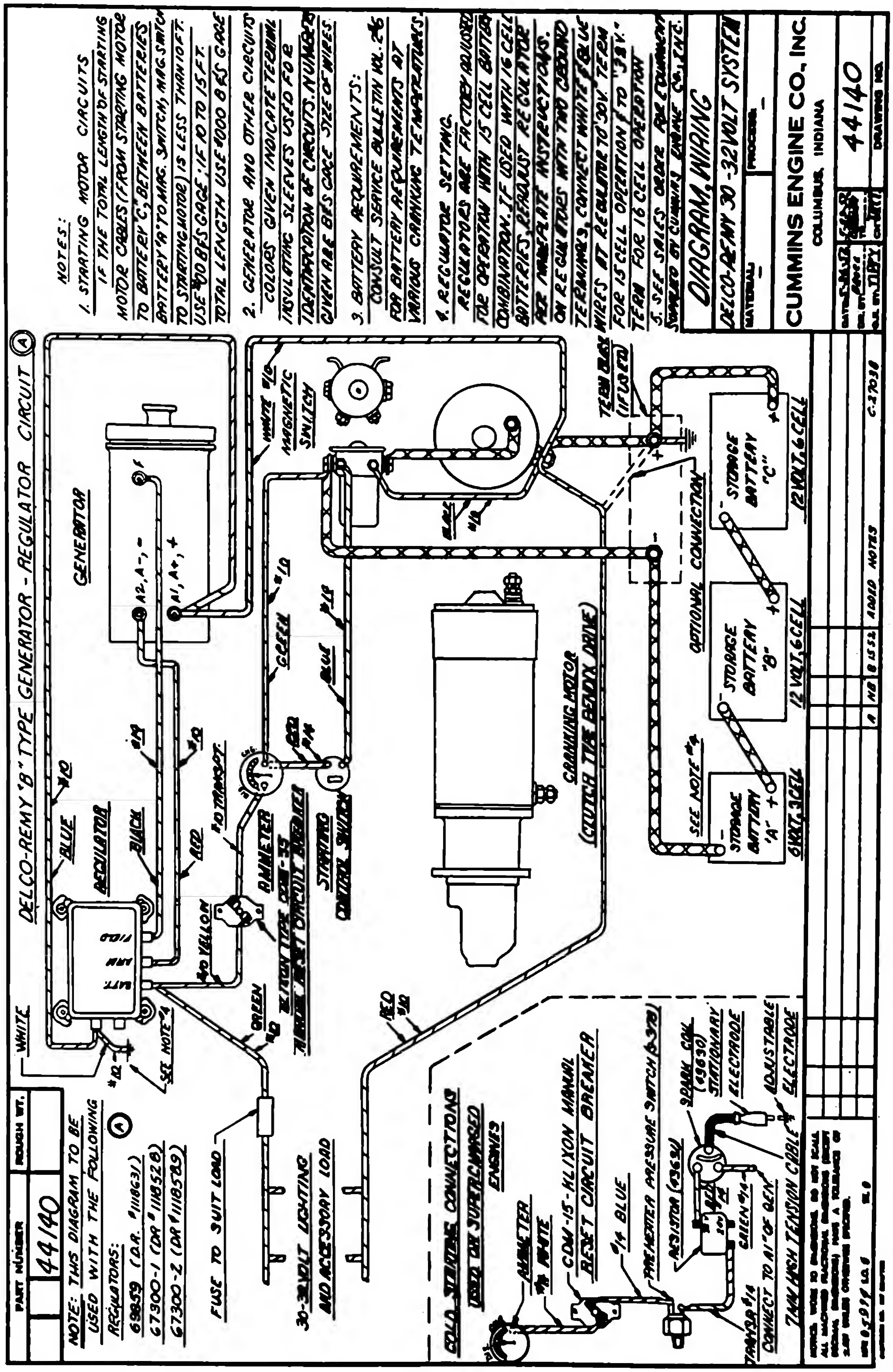


Fig. 11-27. 32 volt, 15 amp. Delco-Remy System with Bendix Drive starting motor and standard duty magnetic switch. Delco-Remy "B" type Gen./Reg. circuit.

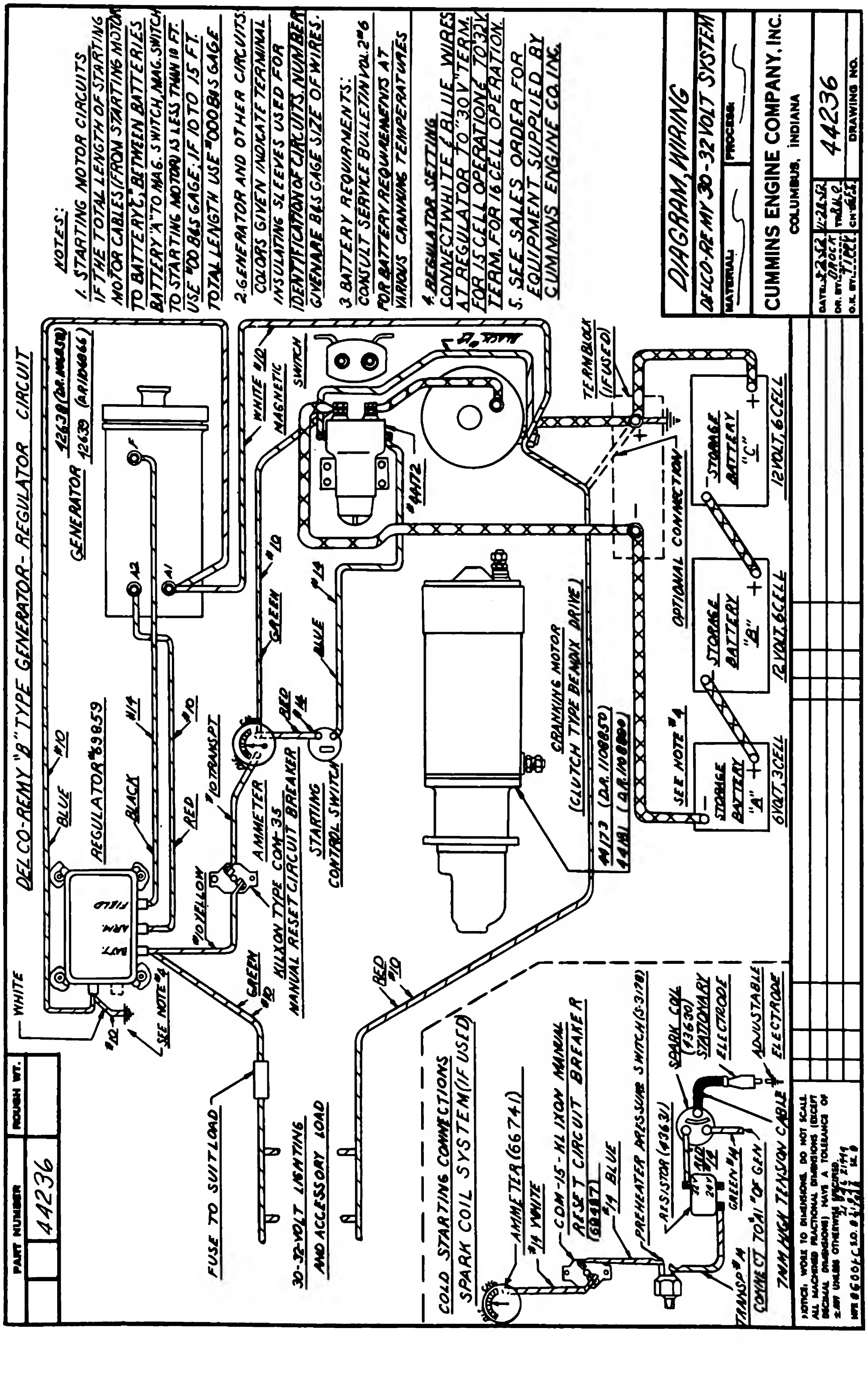
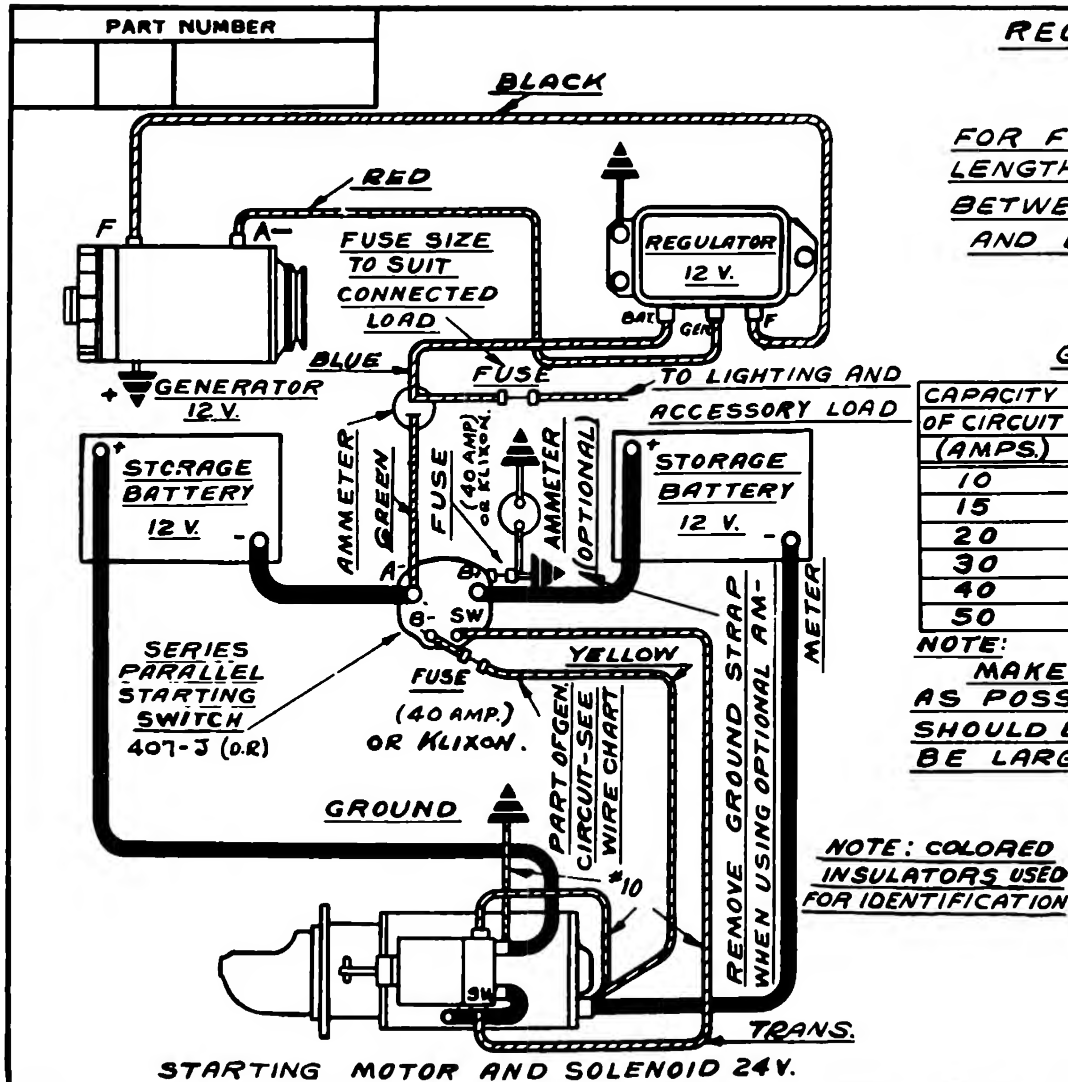


Fig. 11-28. 32 volt, 15 amp. Delco-Remy System with Bendix Drive starting motor and heavy duty magnetic switch. Delco-Remy "B" type Gen./Reg. circuit.

Fig. 11-29. 12-24 volt, 120, 240, 375, 600 and 825 watt Delco-Remy Series Parallel System, with Foot Pedal Starting



RECOMMENDED WIRE SIZES

STARTING MOTOR CIRCUITS

FOR FOLLOWING TOTAL LENGTHS OF CABLE BETWEEN STARTER AND BATTERIES. → USE FOLLOWING WIRE SIZES B & S GAUGE

10 FT. MAX. — — — — — 00
15 FT. MAX. — — — — — 000

GENERATOR CIRCUITS

CAPACITY OF CIRCUIT (AMPS.)	WIRE SIZES NO.12	NO.10	NO.8	NO.6	NO.4	NO.2
	TOTAL LENGTH OF CIRCUIT IN FT.					
10	6.5	10.0	16.0	25.0	40.0	64.0
15		6.5	10.0	17.0	26.0	42.0
20		5.0	8.0	12.5	20.0	32.0
30			5.0	8.5	13.0	21.0
40				6.5	10.0	16.0
50				5.0	8.0	13.0

NOTE:
MAKE STARTING CABLES AS SHORT AS POSSIBLE. EXTRA SWITCHES, ETC. SHOULD BE AVOIDED BUT IF USED SHOULD BE LARGE ENOUGH TO CARRY 500 AMPS.

DELCO REMY DWG #LA-1351

WIRING DIAGRAM
SERIES PARALLEL

MATERIAL | PROCESS

CUMMINS ENGINE CO.
COLUMBUS, INDIANA

DATE: 8-10-38 | 8-6-42
DR. BY NHN | TR. D.J.S
O.K. BY NHN | CH'D J.S

61622
DRAWING NO.

NOTICE:—WORK TO DIMENSIONS.—DO NOT SCALE ALL MACHINED DIMENSIONS HAVE A TOLERANCE OF ± .007" UNLESS OTHERWISE SPECIFIED.

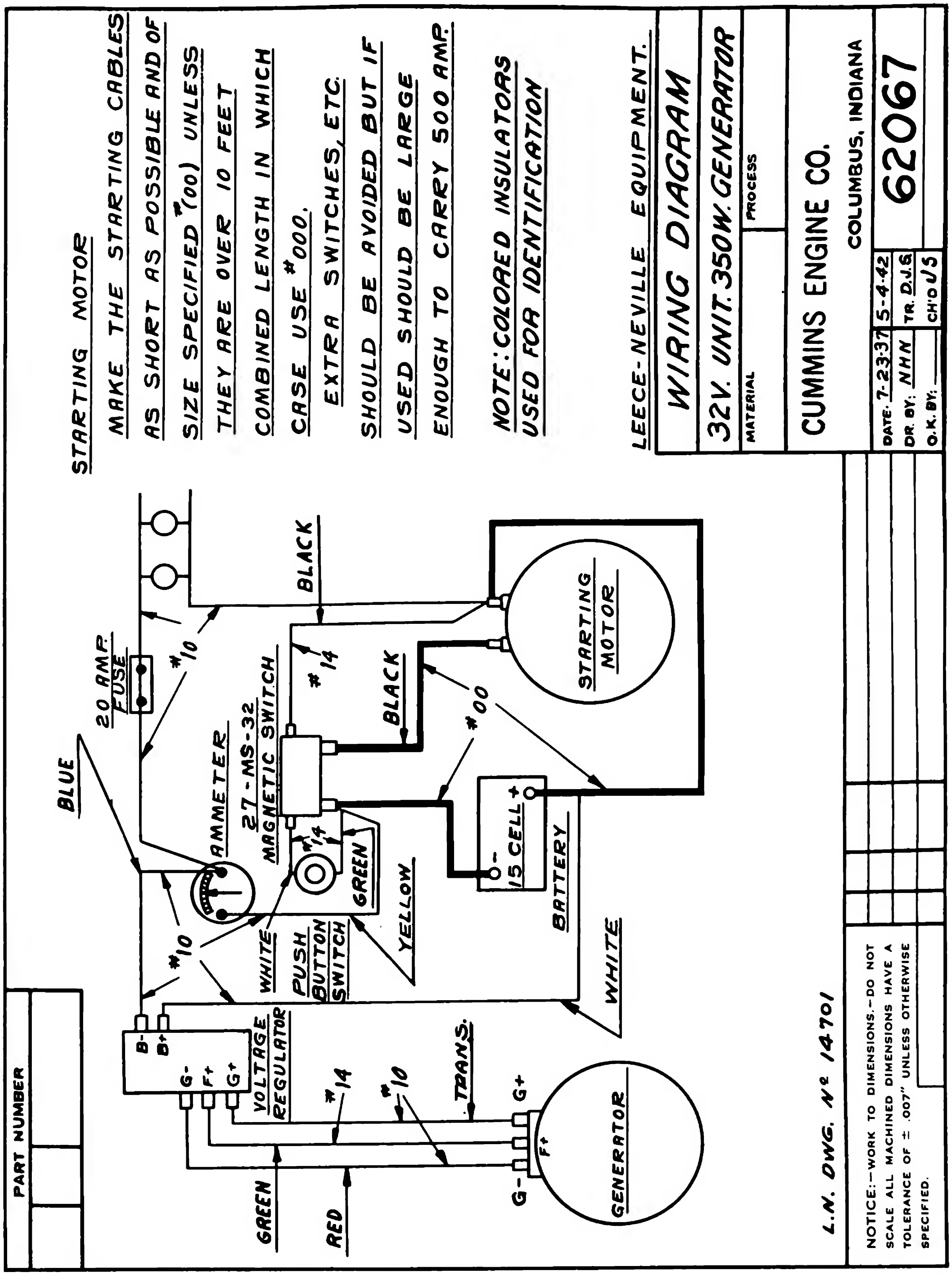
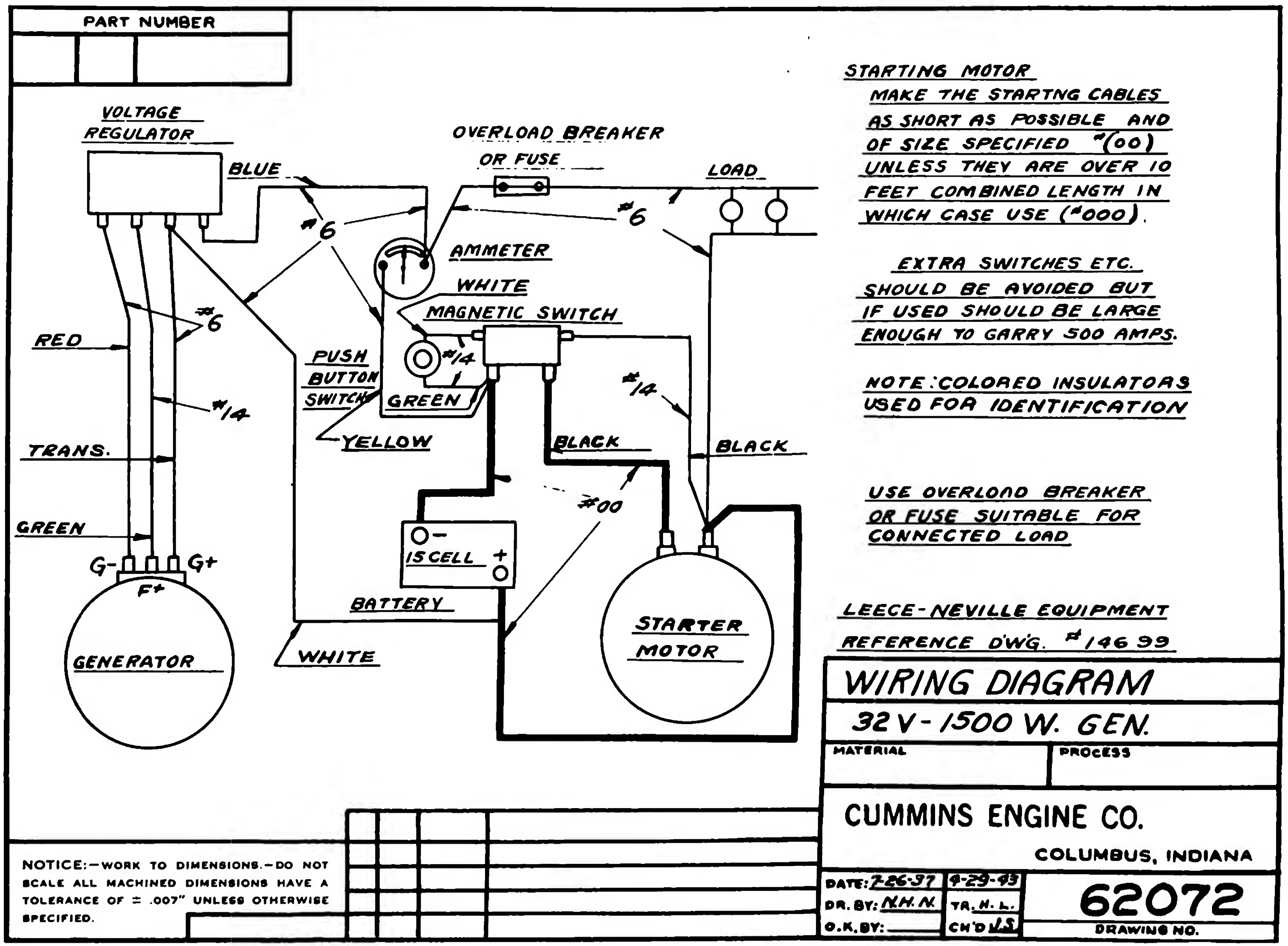


Fig. 11-30. 32 volt; 350 watt Leece-Neville Insulated System with Push Button Starting

Fig. 11-31. 32 volt; 1500 watt Leece-Neville Insulated System with Push Button Starting



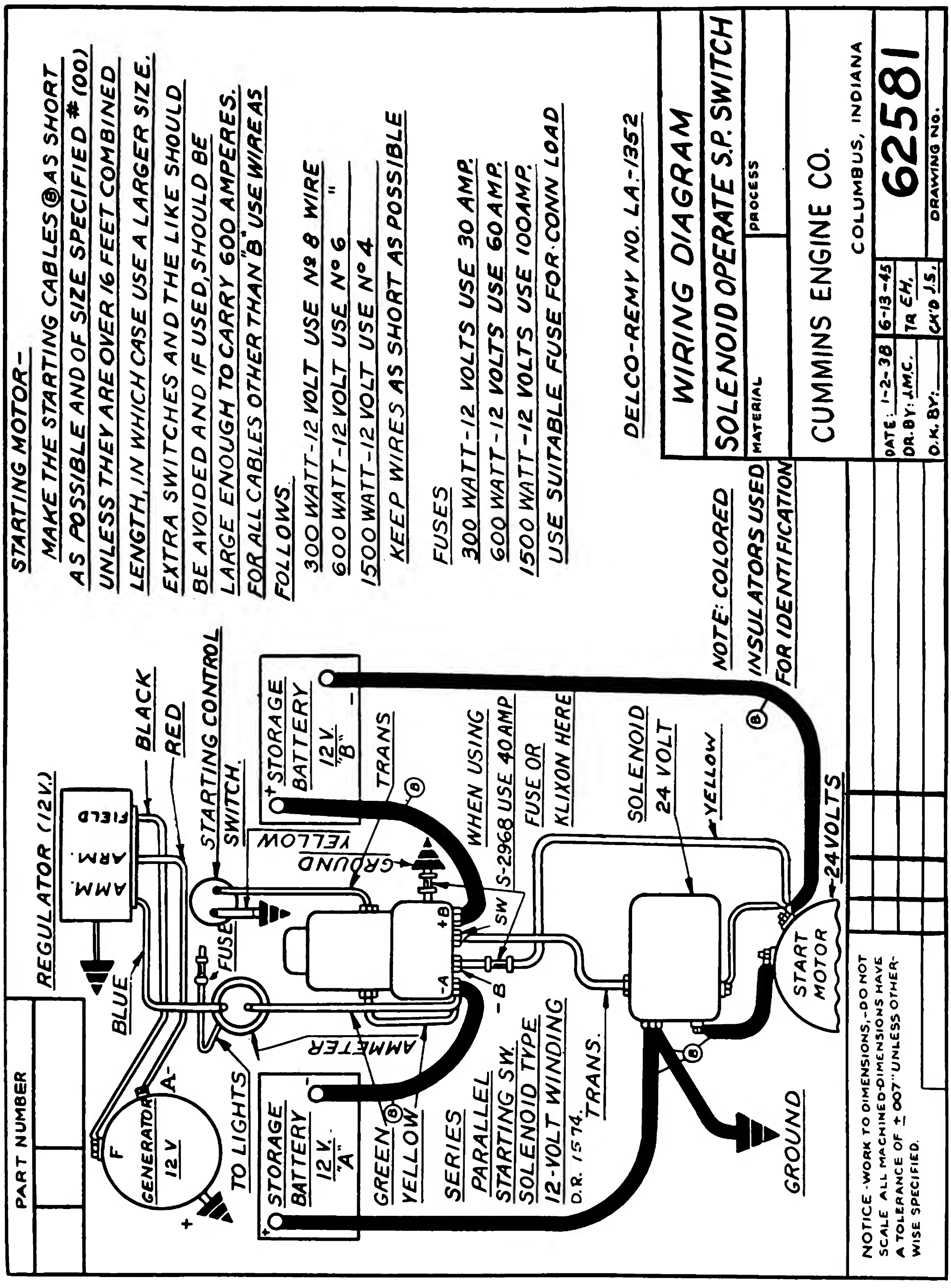
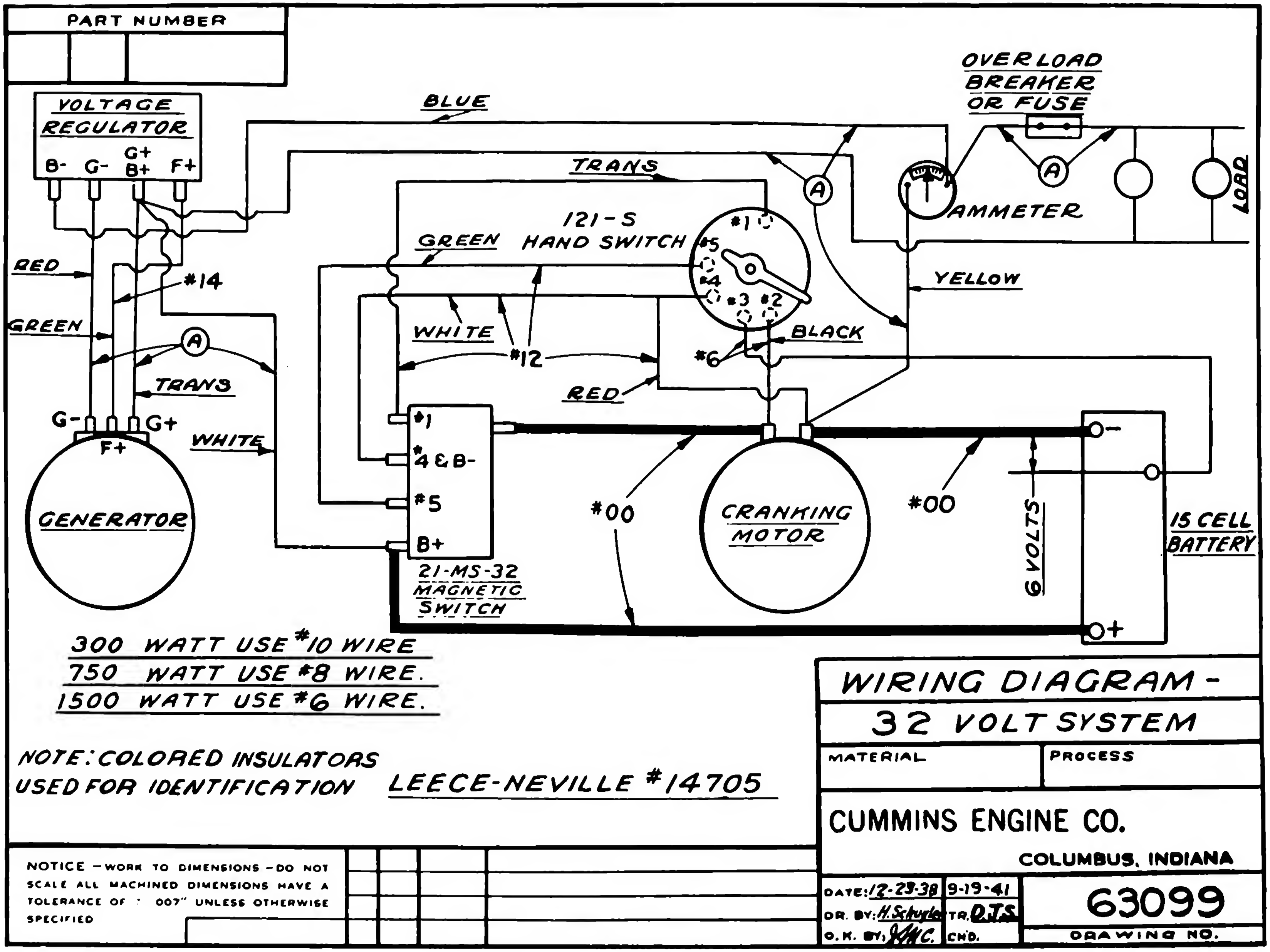
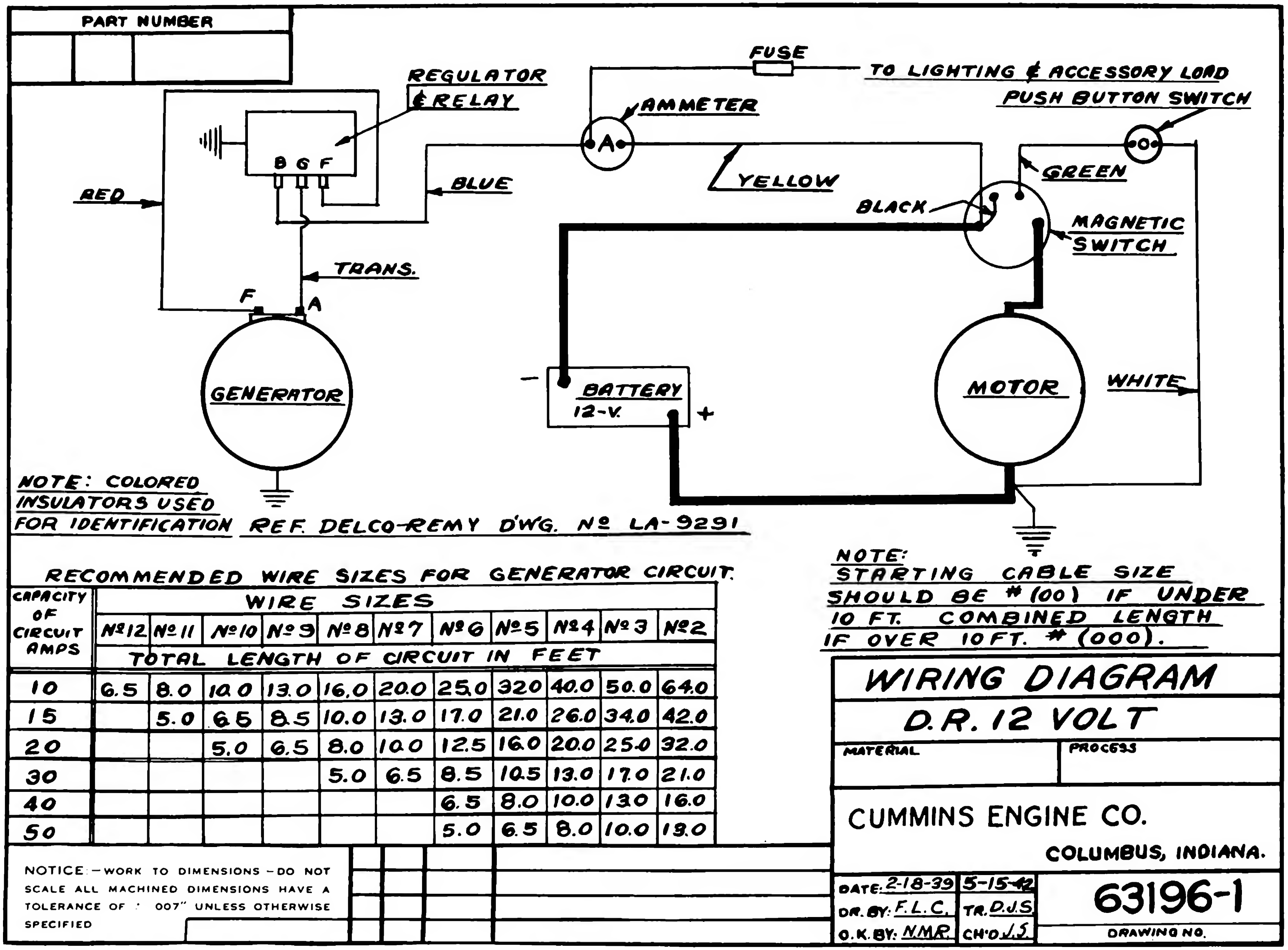


Fig. 11-32. 12-24 volt; 120, 240, 375, 600 and 825 watt Delco-Remy Series Parallel System, with Push Button Starting

Fig. 11-33. 32 volt; 350, 750 and 1500 watt Leece-Neville Insulated System with Two Stage Switch Starting



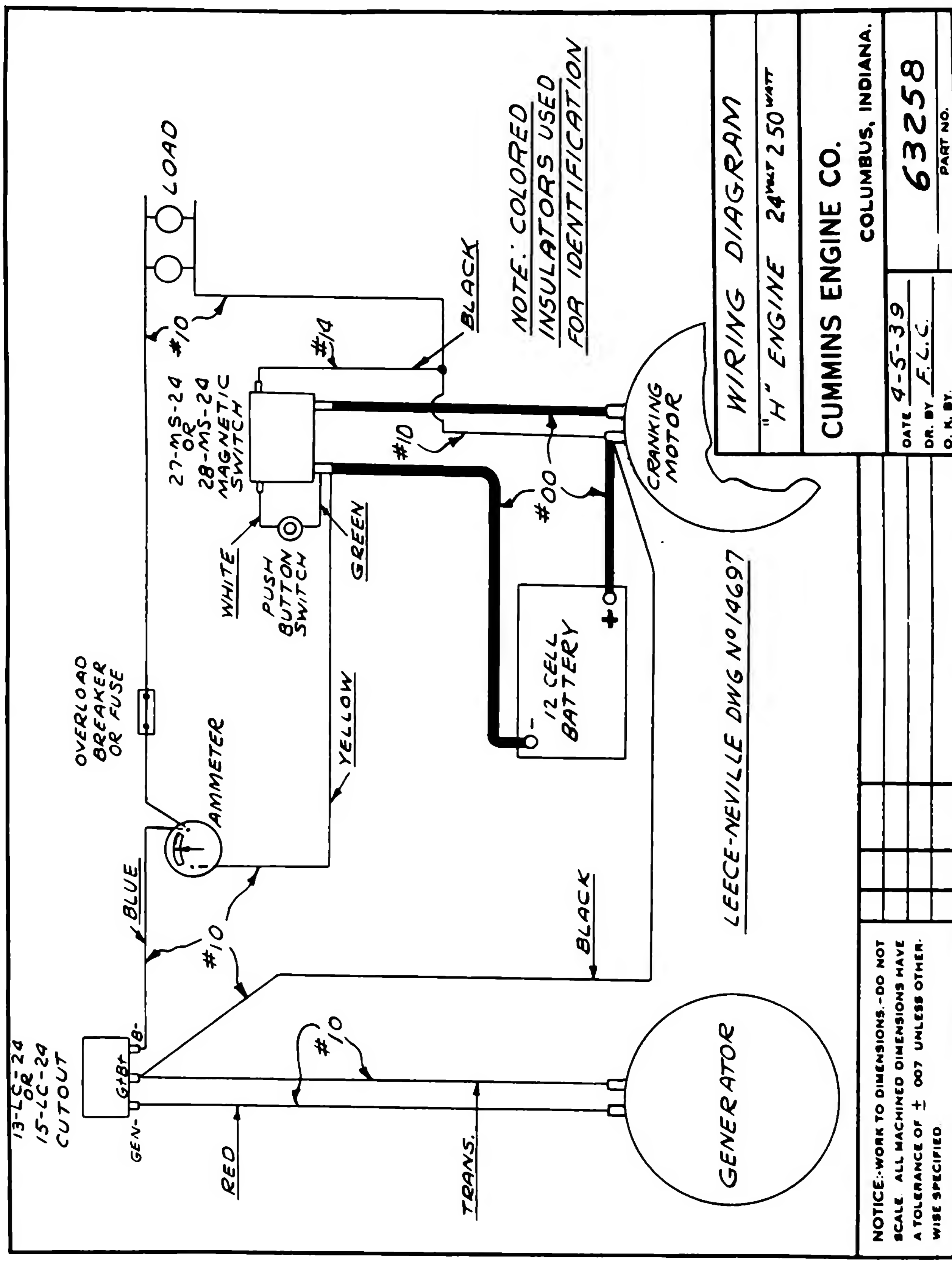


RECOMMENDED WIRE SIZES FOR GENERATOR CIRCUIT.

CAPACITY OF CIRCUIT AMPS	WIRE SIZES										
	№12	№11	№10	№9	№8	№7	№6	№5	№4	№3	№2
	TOTAL LENGTH OF CIRCUIT IN FEET										
10	6.5	8.0	10.0	13.0	16.0	20.0	25.0	32.0	40.0	50.0	64.0
15		5.0	6.5	8.5	10.0	13.0	17.0	21.0	26.0	34.0	42.0
20			5.0	6.5	8.0	10.0	12.5	16.0	20.0	25.0	32.0
30					5.0	6.5	8.5	10.5	13.0	17.0	21.0
40							6.5	8.0	10.0	13.0	16.0
50							5.0	6.5	8.0	10.0	13.0

Fig. 11-34. 12 volt; 250, 375, 600, 825 watt Delco-Remy Grounded System with Push Button Starting

Fig. 11-35. 24 volt; 250 watt Leece-Neville Insulated System with Cut Out Relay and Push Button Starting



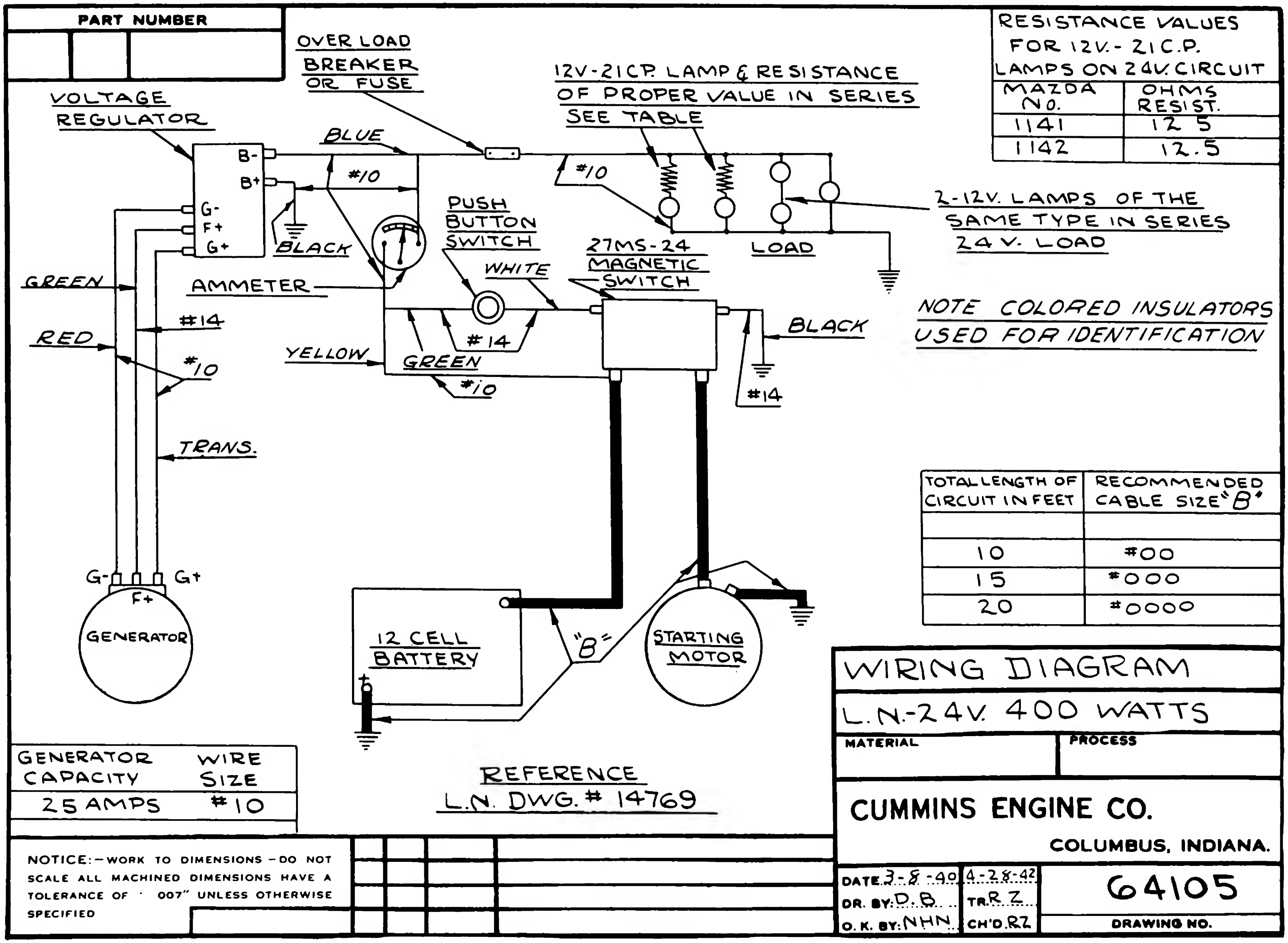


Fig. 11-36. 24 volt; 250 and 400 watt Leece-Neville Grounded System with Push Button Starting. (Also 12 volt 700 watt)

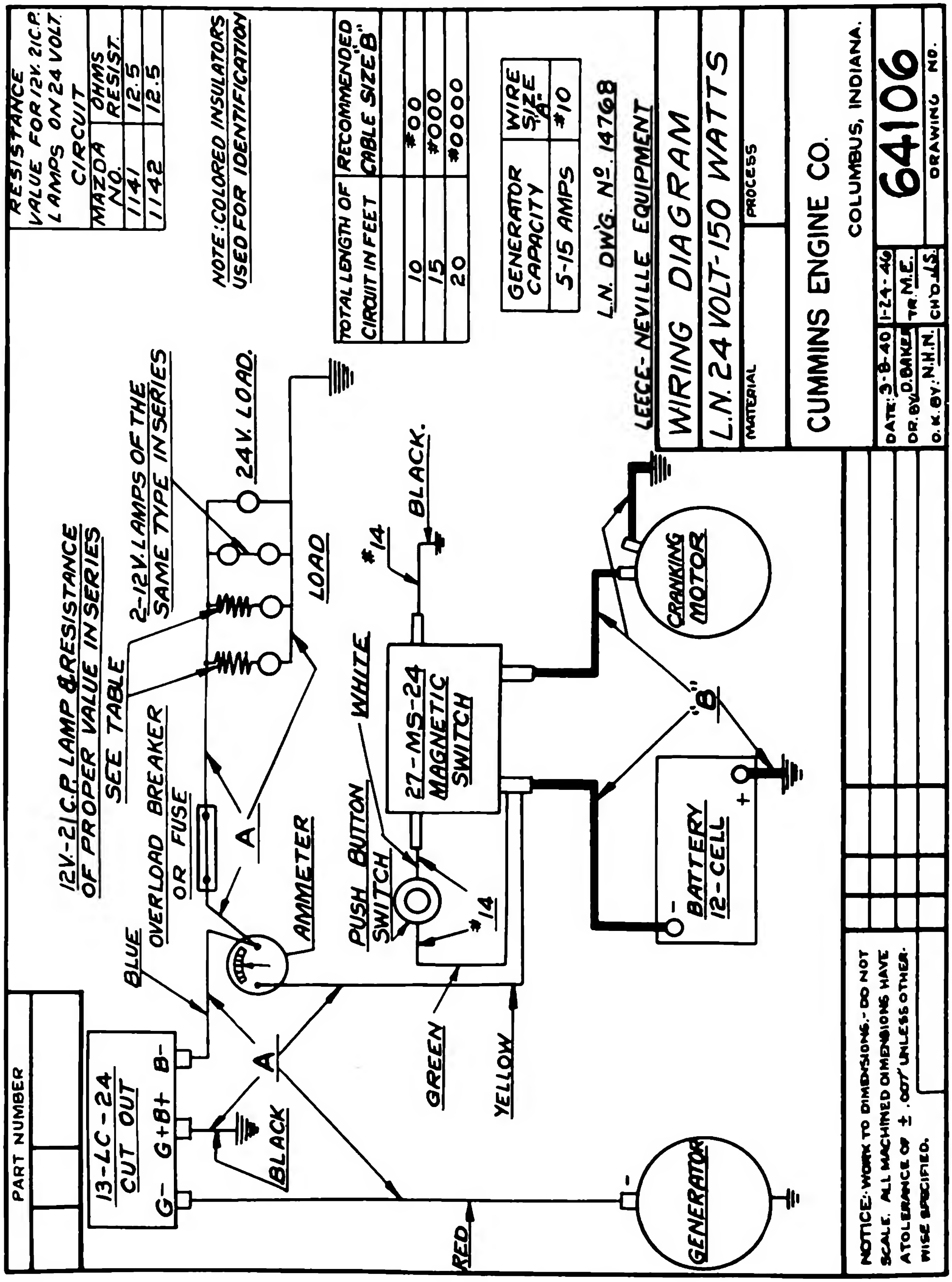


Fig. 11-37. 12 and 24 volt; 150 watt Leece-Neville Grounded System with 3rd Brush Generator, Cut Out Relay and P.B. Starting

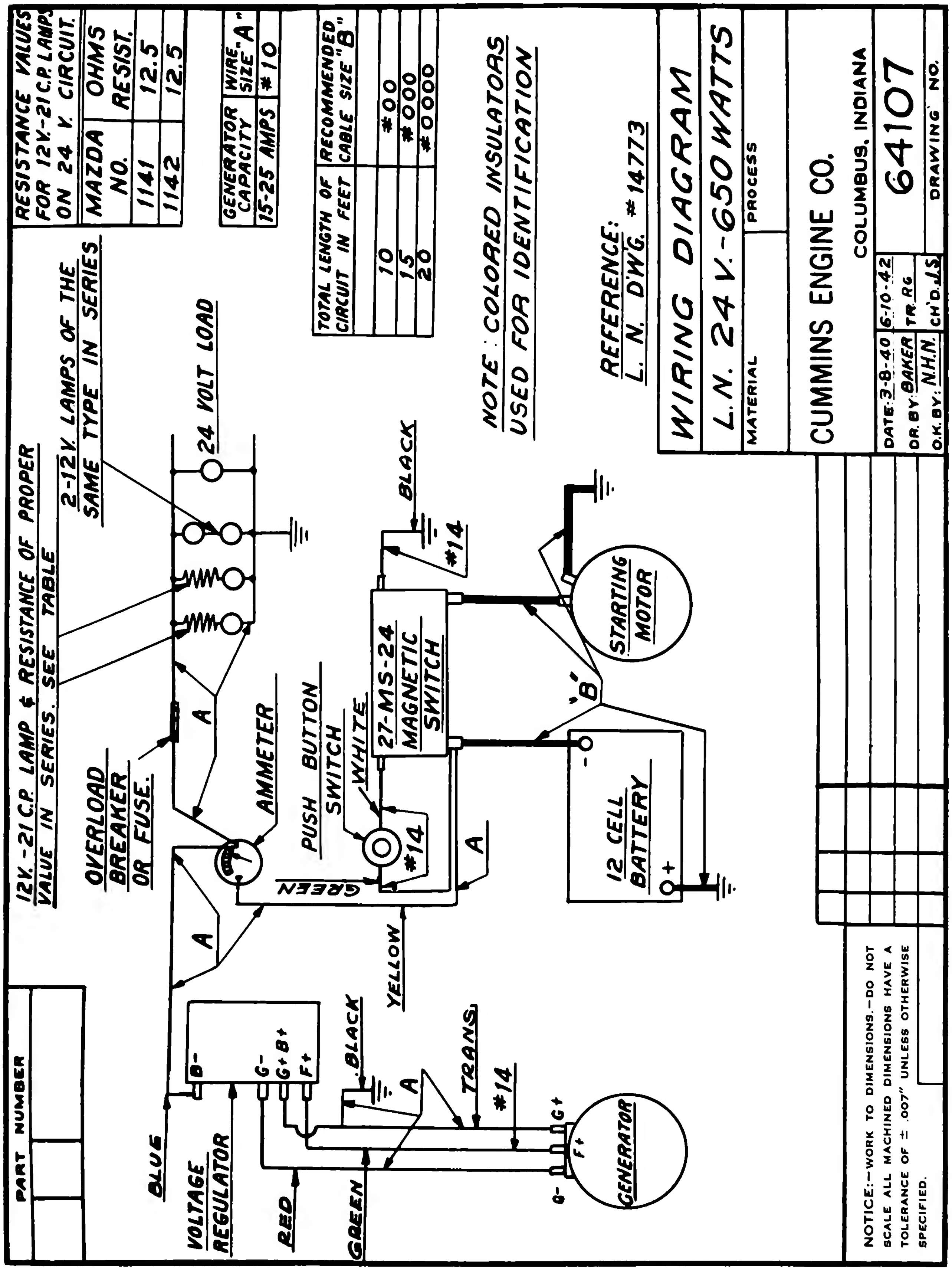
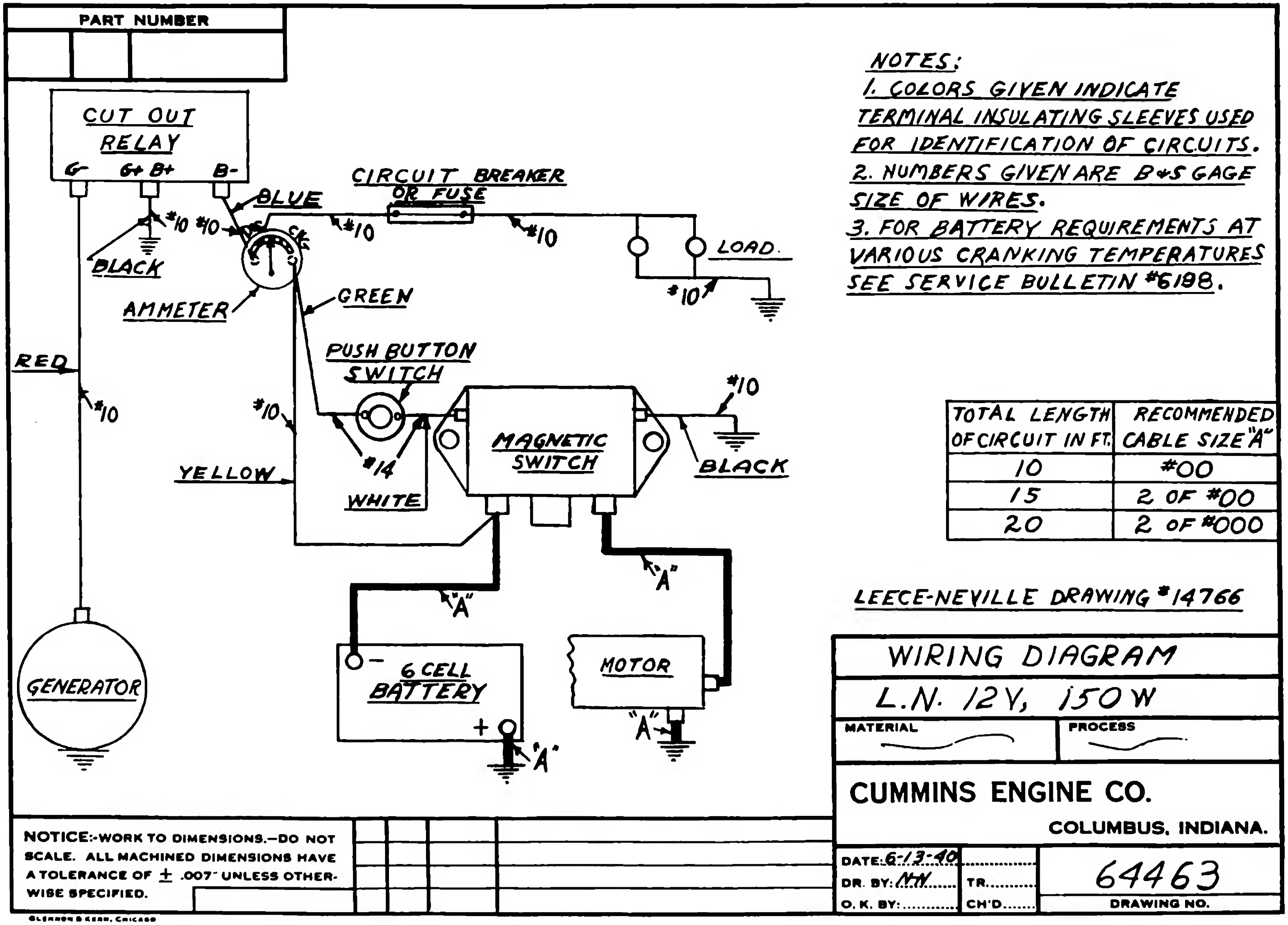


Fig. 11-38. 24 volt; 650 watt Leece-Neville Grounded System with Push Button Starting

Fig. 11-39. 12 volt; 150 watt Leece-Neville Ground System with Cut-Out Relay and Push Button Starting



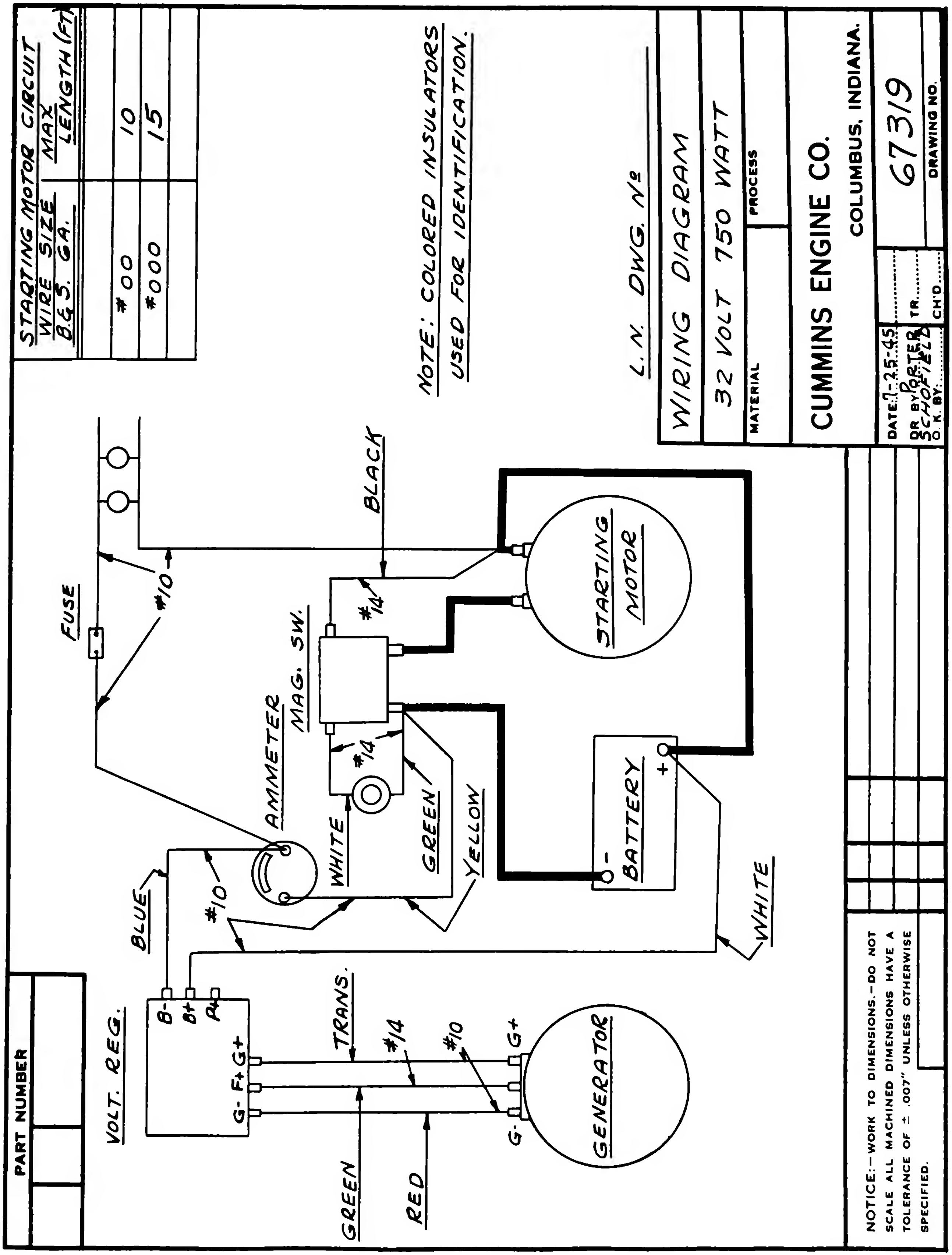
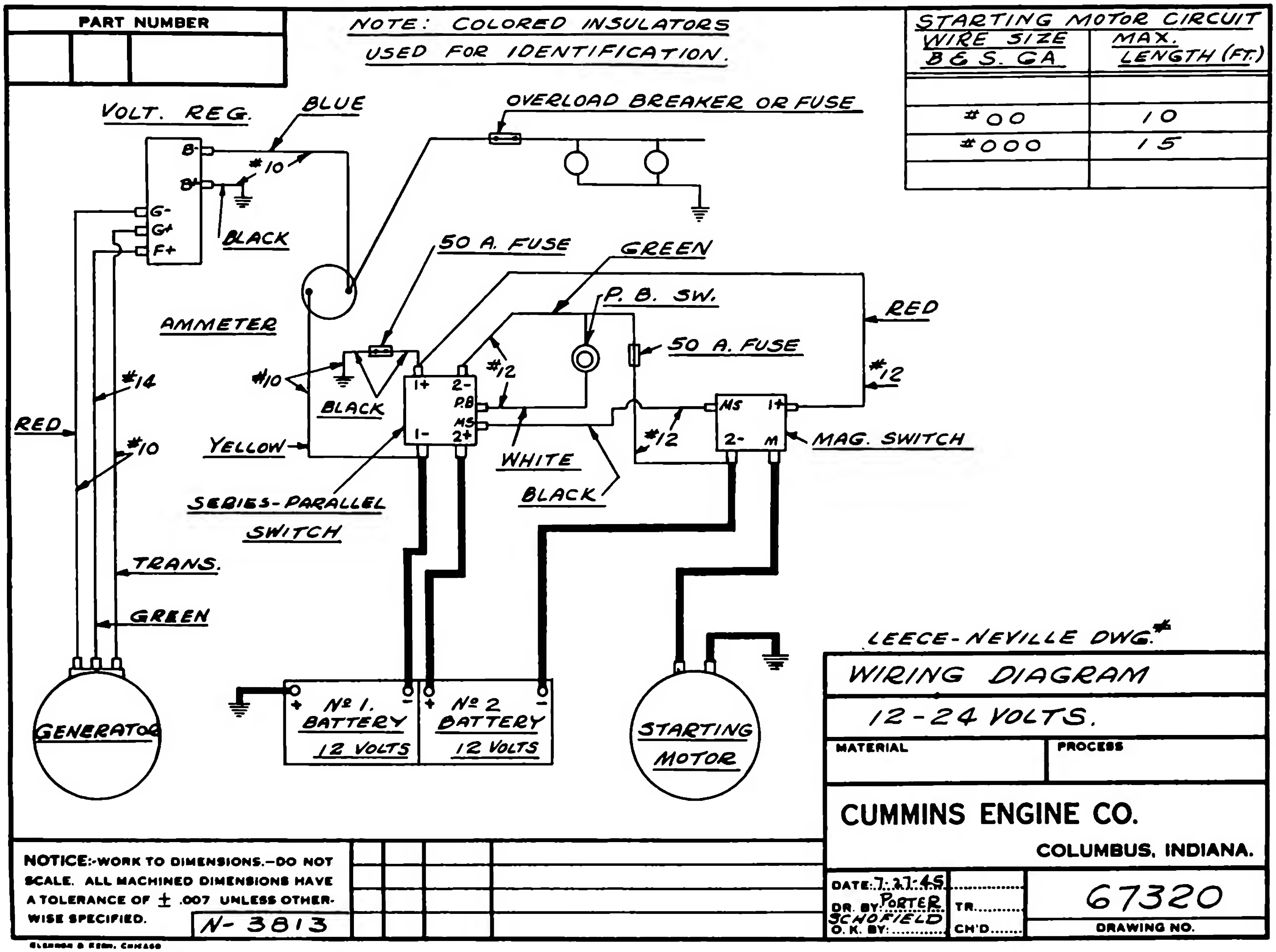


Fig. 11-40, 32 volt; 350 and 750 watt Leece-Neville Insulated System with Heavy Duty Regulator and P. B. Starting

Fig. 11-41. 12-24 volt; 500 and 700 watt Leece-Neville Series Parallel System with Heavy Duty Regulator (+ Grounded)



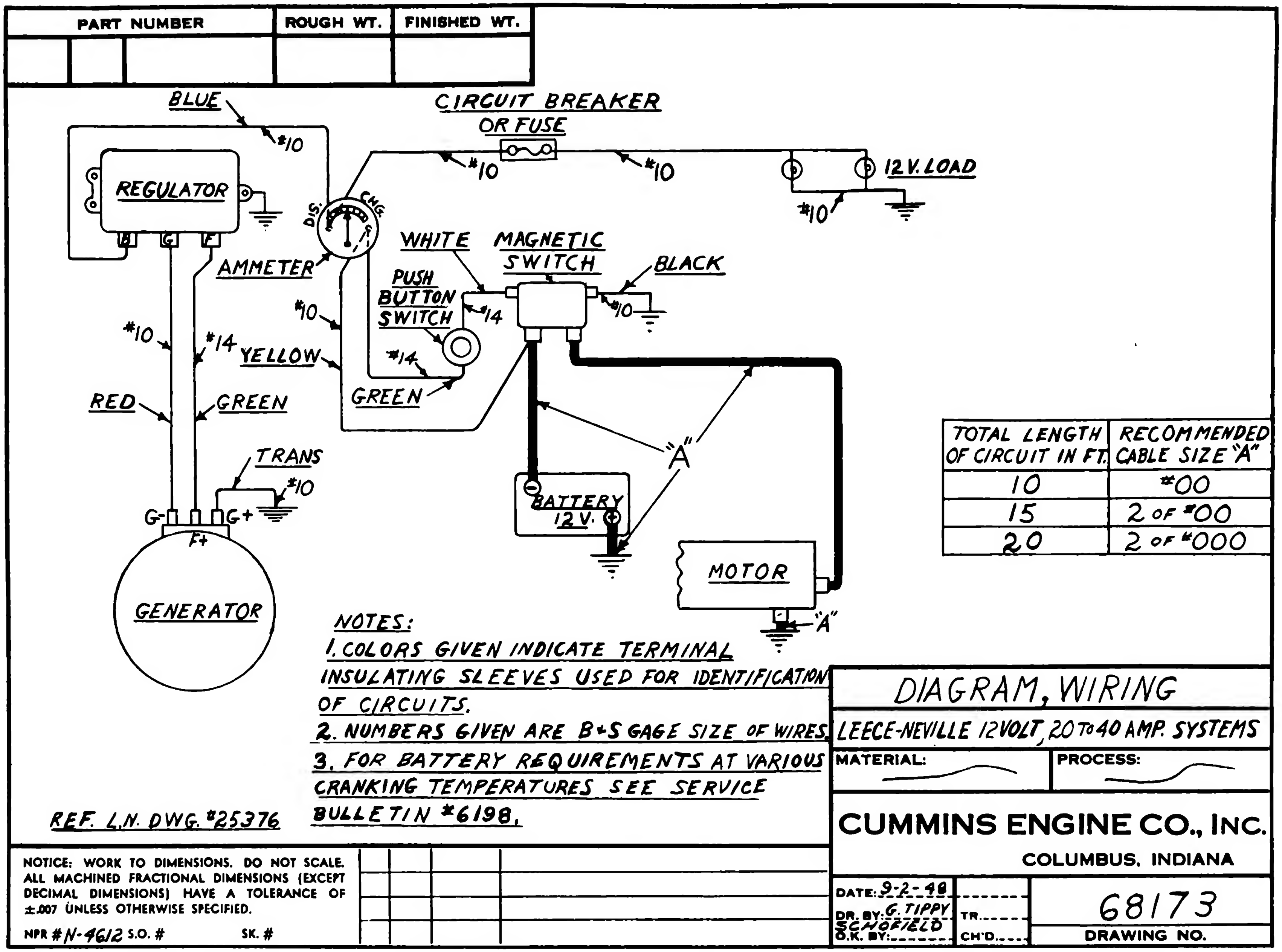


Fig. 11-42. 12 volt; 250 to 500 watt; 20 to 40 ampere Leece-Neville System with Small 3-element Regulator and Push Button Starting

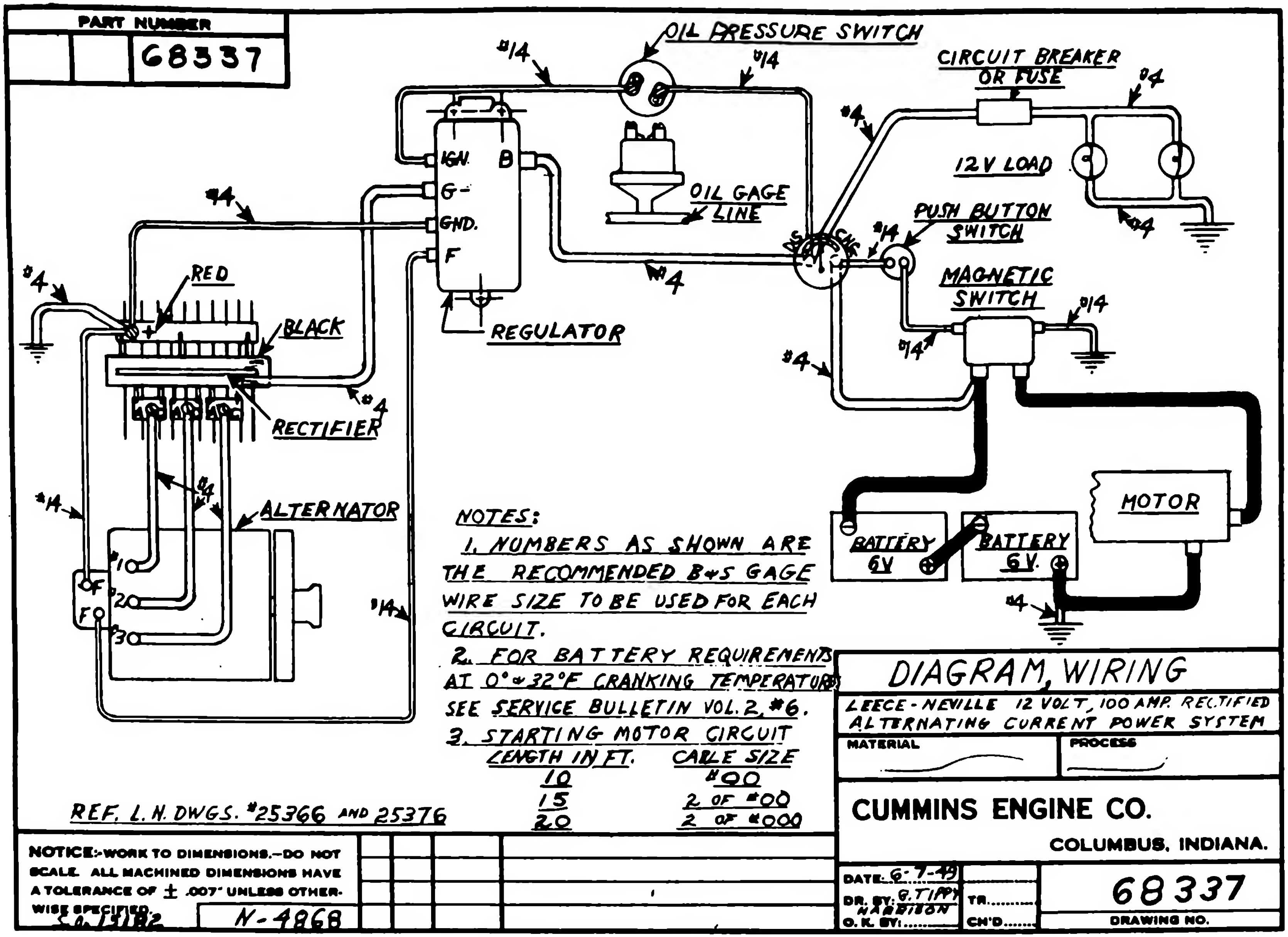


Fig. 11-43. 12 volt; 100 ampere; 1400 watt Leece-Neville Rectified Alternating Current Power System

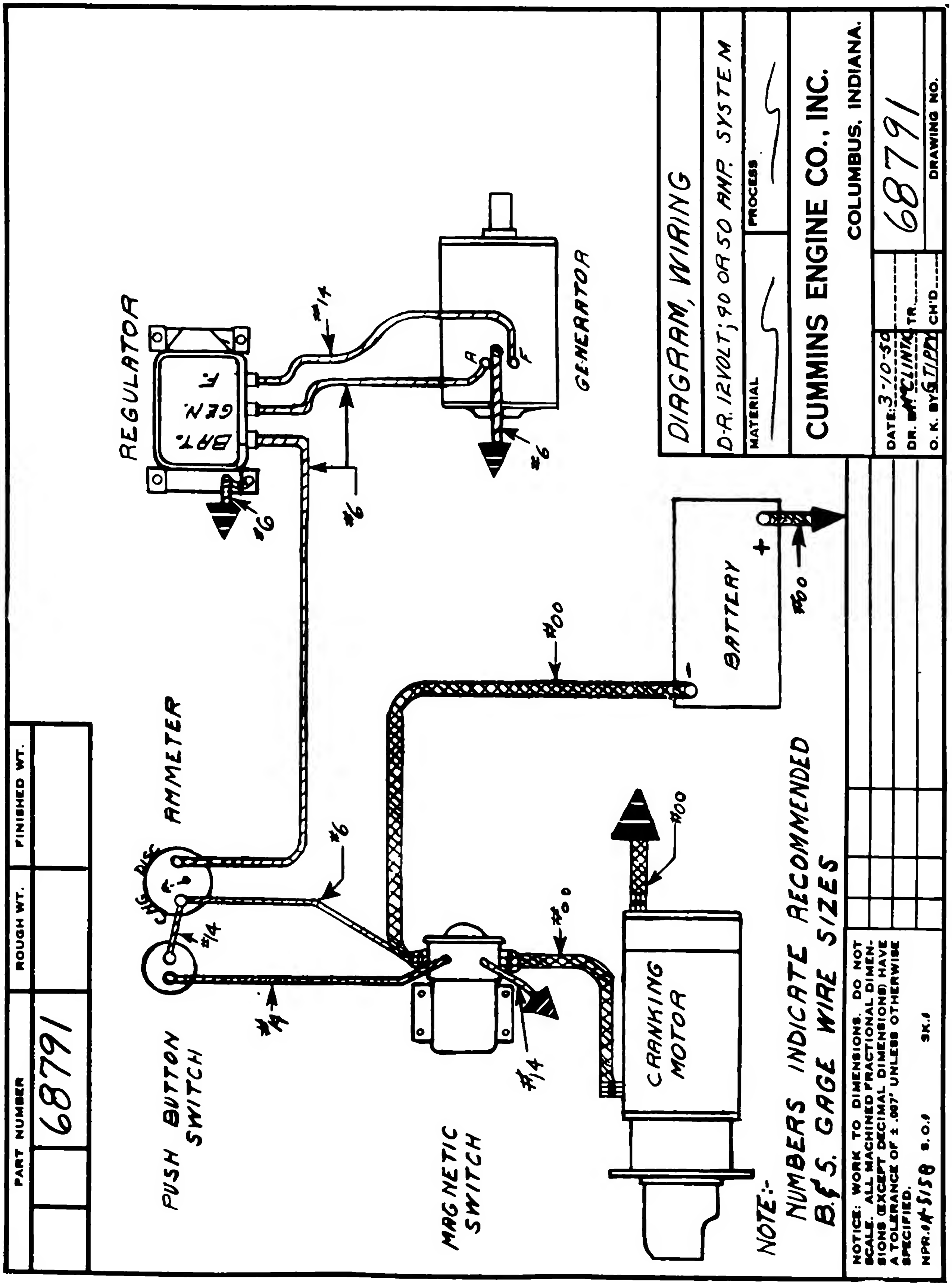


Fig. 11-44. 12 volt; 40 or 50 ampere; 560 or 700 watt Delco-Remy with Standard 3-element Regulator and P. B. Starting

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SECTION XII

UNIT NO. 14

Complete Engine Assembly

The material in this section deals with (1) the assembly of the remaining units to the cylinder block group and (2) adjustments and testing of the engine.

In this section, instructions are given for the assembly of both single-disc and double-disc fuel pumps, and of all units which may be used on any of the engines included in this manual.

ASSEMBLY

Cylinder Block Group

1. The cylinder block group should be assembled according to the instructions in SECTION II. This includes assembly of:
   - Cylinder Block
   - Cylinder Liners
   - Crankshaft and Main Bearings
   - Camshaft and Camshaft Bearings
   - Rear Cover
   - Connecting Rods and Pistons
   - Idler Gear
   - Gear Case Cover
   - Compression Release Lever
   - Hand Hole Covers
2. The cylinder block group should be secured to an engine stand for assembly of remaining units.

Cylinder Heads

1. Cylinder heads should have valve guides, valves and springs assembled in position as instructed in SECTION III.
2. Make sure that H and NH cylinder heads have the top breather hole open. HS, NHS and NHRS heads must have the breather hole plugged with a 1/8" Allen pipe plug. The breather hole is located at the top of the cylinder head and between the center stud holes. Fig. 12-1.
3. Wipe clean the mating surfaces of the cylinder block and the cylinder heads.
4. Make sure cylinder walls are clean and well lubricated with clean lubricating oil.

SINGLE-PIECE HEAD GASKET: There are two types of head gaskets currently being used on H and NH engines; the single-piece steel-asbestos gasket and a three-piece gasket for each cylinder head, consisting of a carrier-plate and two sealing-rings. To install the one-piece gasket:

1. Make sure the cylinder block and cylinder head mating surfaces are clean.
2. Lower a gasket over the head studs and assemble the cylinder head in place.

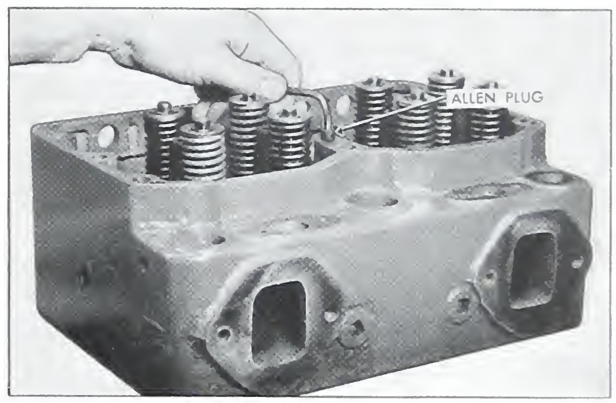


Fig. 12-1. Breather hole in cylinder head

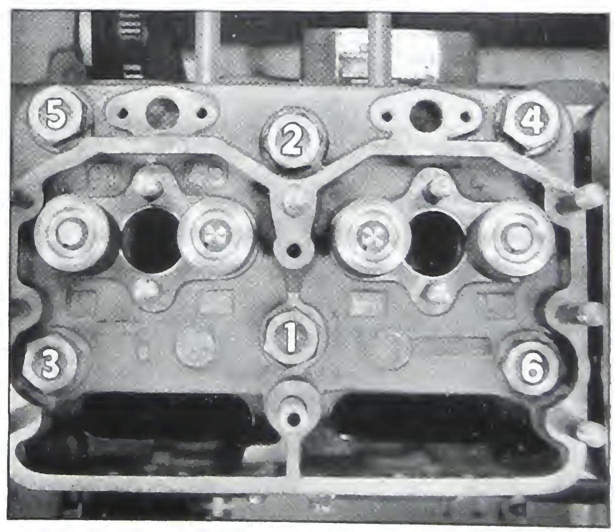


Fig. 12-2. Routine for tightening cylinder head nuts

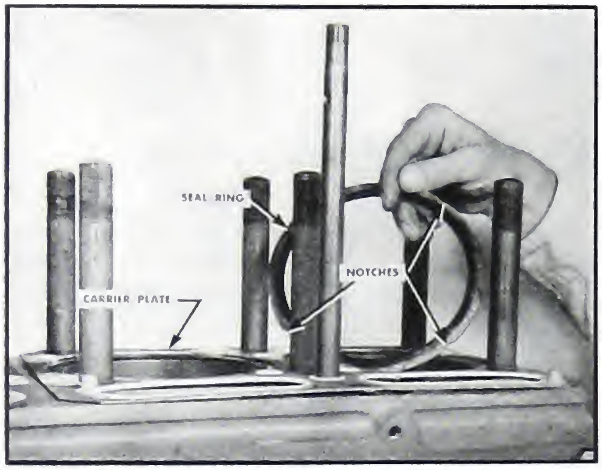


Fig. 12-3. Installing the carrier-plate gasket

3. Lubricate the head stud threads with clean lubricating oil.

4. Install the head stud nuts and tighten to 225/275 foot-pounds in order shown in Fig. 12-2.

5. After Step 4 has been completed, tighten all nuts to 350/400 foot pounds. Final tighten all nuts in rotation, to 430/450 foot pounds.

6. Assemble two cork gaskets over each lubricating oil tube and into the counterbore in the cylinder head.

NOTE: With the steel-asbestos gasket, head stud nuts should be retightened near the end of engine test, again after 10 to 15 hours service, and finally at the first engine oil change.

CARRIER PLATE-SEAL RING HEAD GASKET: NHS AND NHRS ENGINES: 1. Install the carrier-plate over the head studs and check to see that all grommets center around their mating water or oil holes. See Fig. 12-3.

NOTE: Handle the carrier-plates with care to prevent any damage to the grommets. Do not pick any of the excess grommet material from the carrier-plate.

2. Install one compression seal-ring on top of each cylinder liner. These rings must not overlap the carrier-plate and extreme care must be taken to see that the recesses are correctly positioned.

CAUTION: SEAL RINGS WILL FIT IN ONE POSITION ONLY TO PROPERLY CLEAR ALL GROMMETS.

3. Assemble the cylinder head over the head studs, letting it down carefully so the gasket members will not be disturbed.

4. Apply lubricating oil to the nuts and head stud threads; then snug tighten the nuts in place.

5. Tighten the head stud nuts in 50 foot pound increments, in the order shown in Fig. 12-2, to 325/350 foot pounds.

6. No further tightening of stud nuts is required except as a check to see that none were missed.

7. Install two cork gaskets around each lubricating oil pipe.

Cam Follower Lever Assemblies

1. Cam follower lever assemblies must be new or rebuilt and/or checked as directed in SECTION IV. Since rollers of cam follower levers act directly on the camshaft lobes, it is extremely important that proper alignment of lever shafts, rollers and camshaft lobes be maintained. A small amount of misalignment will cause uneven and excessive wear of camshaft lobes, particularly of the injector cam lobe. If proper lever length is not maintained or restored in rebushing the levers, it will be impossible to time the engine properly.

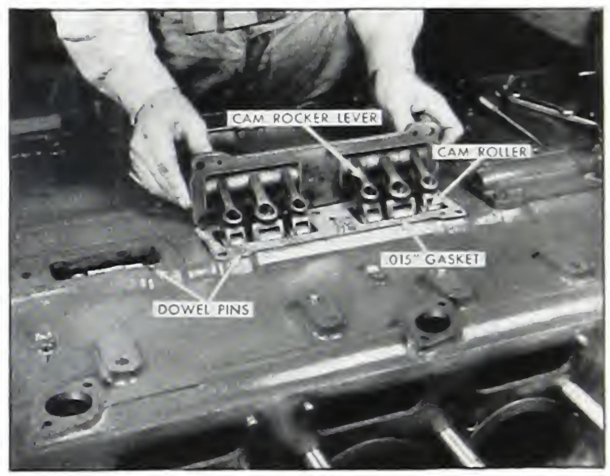


Fig. 12-4. Cam rocker lever assembly

2. Use a new gasket and assemble the lever and housing assemblies to the cylinder block. Secure with lockwashers and capscrews. (Fig. 12-4).

NOTE: A flat head screw and star lock washer must be used in the top middle hole of No. 1 housing to provide clearance for the compressor drive belt on NH series engines.

3. When pressure is applied on cam follower levers, the lever rollers must bear evenly on the camshaft lobes. This alignment can be easily checked with Prussian blue.

4. Gasket thickness regulates injection timing. The reason is that cam follower rollers do not ride directly over the top of the cam lobes. Pulling the levers away from the block advances timing of right-hand engines. This is done by adding an extra gasket. Use gaskets as needed to get the correct timing.

Timing The Engine

Install push rods in their sockets for timing operations. The injector push rod is largest and it goes in the middle socket. The intake valve push rods have collars to match with the milled lift of the compression release. Exhaust push rods are plain.

All H and NH series engines should be timed with fixture ST-300 by the following method.

1. Install timing tool ST-300 in place of an injector, with one rod in a push rod socket and with the other resting on the piston. Bar engine, in direction of rotation, to top center firing position for the cylinder being timed. At point of maximum piston rise, assemble the indicator above the piston to within a few thousandths inch of its fully compressed position.

Set the dial of the indicator to read "0". (Fig. 12-5).

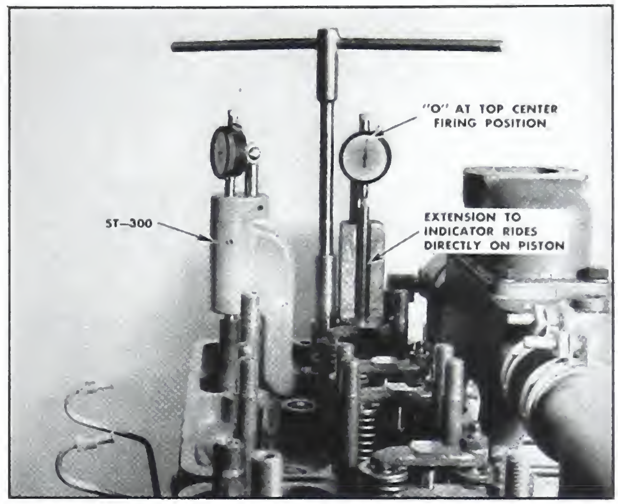
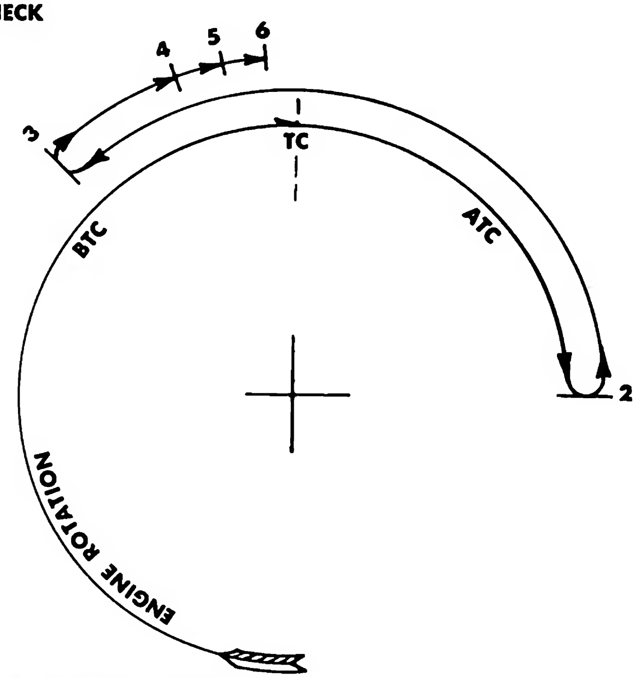


Fig. 12-5. Top center position

NOTE: The two dial indicators used in timing

INJECTION TIMING CHECK
—Use ST-300 Timing Tool—

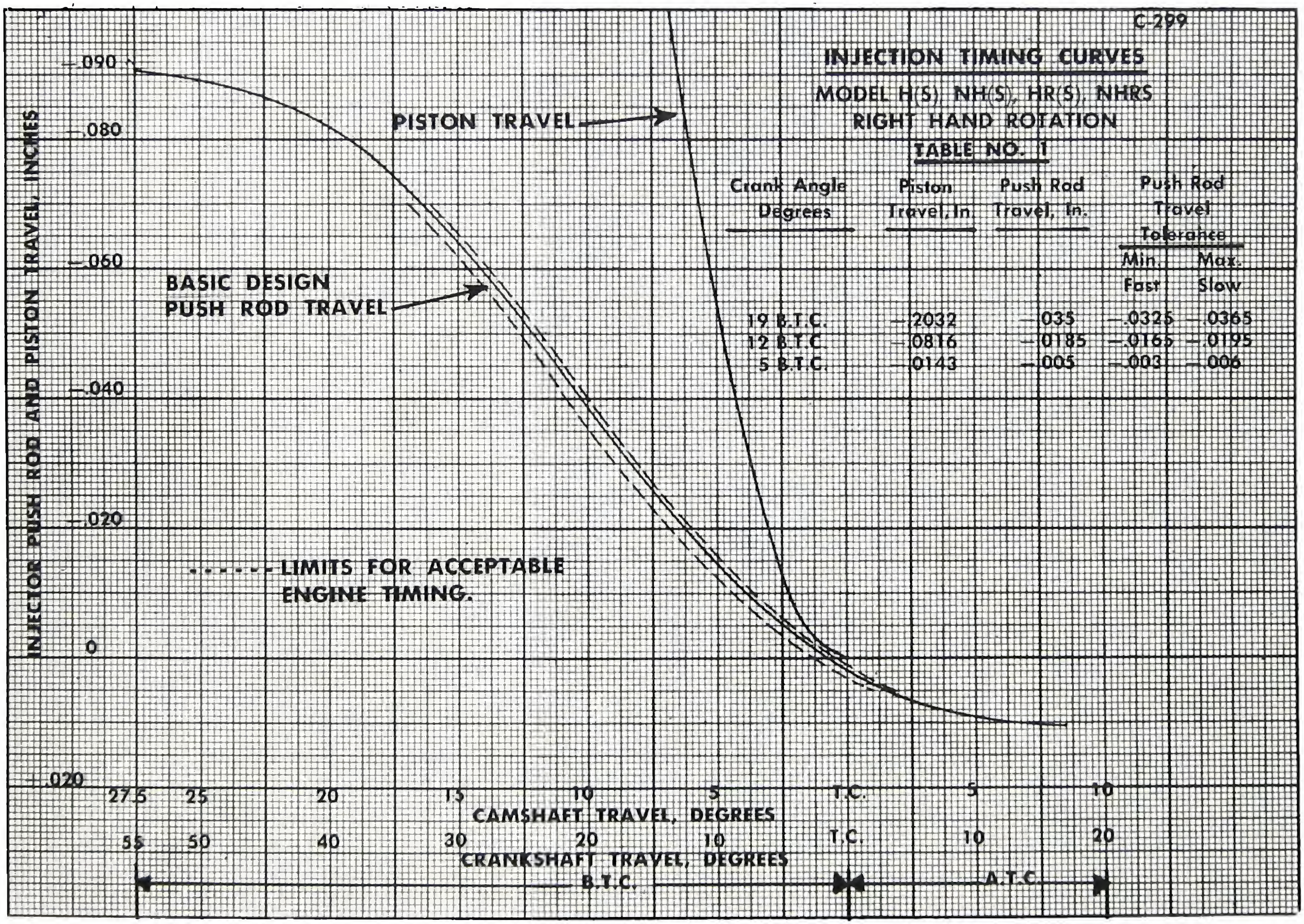
1. **BAR ENGINE TO No. 1 TC FIRING POSITION.**
   Set indicator above piston to "0"
2. **ADVANCE ENGINE TO 90° ATC.**
   Top of tool rod will be at 90° mark.
   Set indicator above push rod to "0".
3. **BAR ENGINE OPPOSITE ROTATION TO 45° BTC.**
   This is to take up gear lash.
   Top of tool rod will be at 45° mark.
4. **BAR ENGINE FORWARD UNTIL PISTON IS ONLY .2032 LOWER THAN AT TOP CENTER POSITION.**
   This is 19 BTC.
   Push rod must be .0325 to .0365 lower than at 90° ATC.
5. **CONTINUE TO BAR ENGINE FORWARD UNTIL PISTON IS ONLY .0816 LOWER THAN AT TOP CENTER POSITION.**
   This is 12° BC.
   Push rod must be .0165 to .0195 lower than at 90° ATC
6. **CONTINUE TO BAR ENGINE FORWARD UNTIL PISTON IS ONLY .0143 LOWER THAN AT TOP CENTER POSITION.**
   This is 5° BTC.
   Push rod must be .003 to .006 lower than at 90° ATC.



If indicator above push rod does not read within the limits specified in Steps 4, 5, and 6, it will be necessary to add or remove gaskets from the cam boxes.

Fig. 12-6. Diagram—engine timing procedure

Fig. 12-7. Timing curves



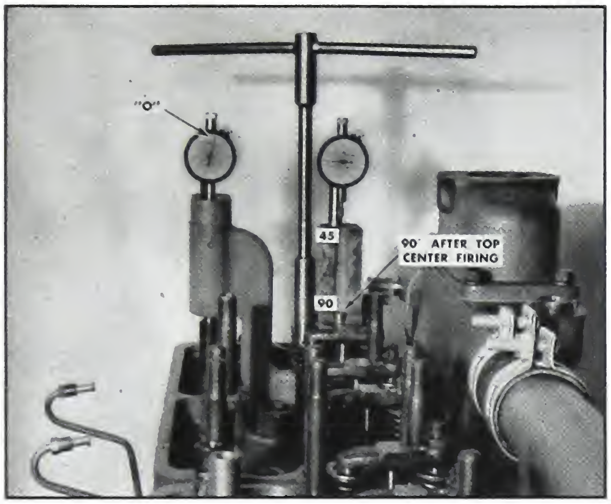


Fig. 12-8. 90° ATC position

the engine must each have a total travel of at least .250.

2. Bar engine in direction of rotation 90° after top center. At this point the mark on the moving plunger will be in line with the 90 degree mark on the plunger retainer above the piston.

3. Using the same method as previously described, set the indicator above the push rod to within a few thousandths inch of its fully compressed position. Set the dial to read "0". (Fig. 12-8).

4. Bar the engine in direction opposite rotation to approximately 45° BTC or until the 45° mark on the plunger of the gauge above the piston is in line with the groove on the retainer. This will be the second time the 45° mark indexes, that is from 90° ATC the piston will travel past 45° ATC, past TC, and to 45° BTC.

5. Bar the engine in direction of rotation until the indicator above the piston reads –.2032. (Fig. 12-6). This is 19° BTC or .2032 lower than top center position. At this point the indicator above the push rod should read between –.0325 and –.0365 as shown by the first check point under "Piston Travel" in Table No. 1 of Timing Curve C-299.

6. Check push rod travel against piston travel at each of the two remaining points shown in Fig. 12-6 and Fig. 12-7.

7. If the downward travel of the push rod (from the 90° ATC position) is greater than the limits shown in the table, engine timing is slow. It can be corrected by adding gaskets, No. 9266. between the cam follower housing and cylinder block. The addition of one gasket advances the timing approximately 1°. If the downward travel of the push rod is less than the limits shown in the table, timing is fast and extra gaskets should be removed to bring the timing within the limits of Table No. 1. (Fig. 12-7).

8. If more than three gaskets are used between the cam follower housing and cylinder block, it may be necessary to machine stock from the compression release lever at the points nearest the injector push rods to prevent interference.

Flywheel Housing

1. The gasket on the flywheel housing is a seal for the camshaft bore. This gasket should be put on the housing with gasket cement and allowed to dry so it will not slip. Any slipping of the gasket will allow oil to leak out at the back end of the camshaft bearing.

2. Clean the mating surfaces of the flywheel housing and the cylinder block of all dirt and burrs.

3. Inspect the dowels and, if they show evidence of wear or shearing caused by previous operations, pull them. In all cases where a new flywheel housing is being installed, the old dowels must be pulled. Secure the housing to the block with capscrews and lockwashers.

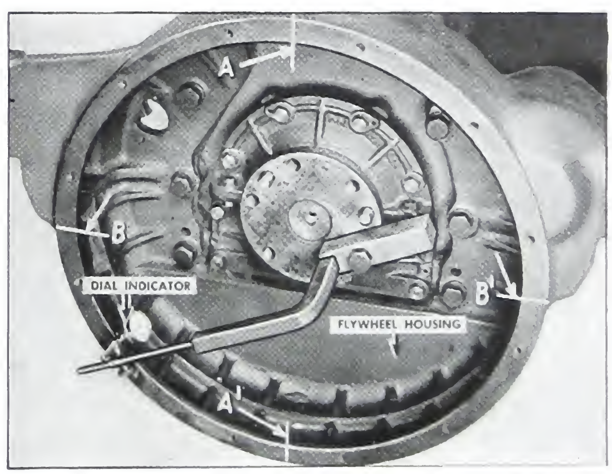


Fig. 12-9. Indicating flywheel housing bore with ST-112 and dial indicator

4. Fasten an indicator to the crankshaft flange as shown in Fig. 12-9 to indicate the bore of the housing.

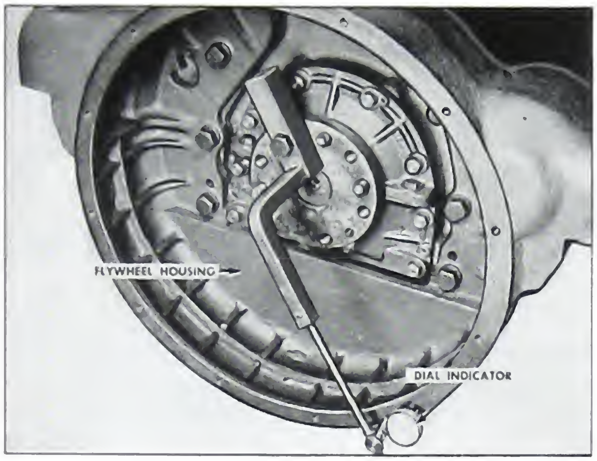


Fig. 12-10. Indicating flywheel housing face

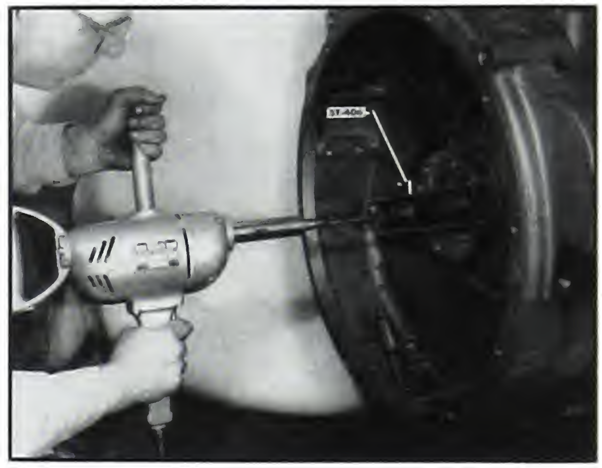


Fig. 12-11. Locating ST-406 to ream dowel holes

5. If the total indicator reading exceeds .004, remove the flywheel housing and pull the dowels, unless they were previously removed. Loosen the capscrews just enough to allow the housing to be shifted. Use a pinch bar to shift the housing to obtain proper indicator reading. The readings at points A and A^1 should be the same and the readings at points B and B^1 should agree. Total indicator reading must not exceed .004.

6. After these readings are obtained, tighten all the capscrews alternately, a little at a time, and recheck.

CAUTION: BE SURE ALL CAPSCREWS ARE TIGHT.

7. Shift the gauge to indicate the housing face. See Fig. 12-10. Turn the crankshaft to get readings at various points on the face of the housing. Each time before taking a reading, use a pinch bar between a main bearing cap and crankshaft throw to take up crankshaft end clearance. Take up end clearance the same direction each time. The reading taken at various points must not vary more than .008.

8. If the dowels were removed, ream the dowel holes in the housing and block to oversize and drive in oversize dowels.

9. A drill and ream jig, ST-406, is available to locate the drills and reamer for flywheel housing oversize dowels. After the housing is properly located, the jig can be assembled in location and various bushings used for oversize drills and reamers. Unless dowel holes are pilot reamed, the new dowels will generally cause the housing to shift.

10. Leave indicator in place to indicate flywheel housing face while installing buttress type oil pan.

Oil Pan

1. Check the oil pan screen to be sure it is properly assembled and all screws are tight.

2. Shellac a new gasket to the oil pan and assemble the pan to the cylinder block with capscrews and bolts. Leave the capscrews and bolts which hold the pan to the block loose until the buttress-type pan has been pulled up tightly to the flywheel housing. If the same pan is being used and if dowel fit bolts have not been removed from the block, the pan should assemble in correct position without distorting the assembled flywheel housing. If a new pan is being installed, it will be necessary to ream the dowel-fit bolt holes to oversize and install oversize dowels.

3. Completely tighten all pan bolts.

NOTE: On engines after Serial No. 85598 the pan mounting holes in the cylinder block are tapped, and capscrews are used instead of bolts.

4. Make sure the flywheel housing is not pulled out of place or distorted, as shown by the indicator gauge.

Flywheel

1. Thoroughly clean the faces of the flywheel and crankshaft flange of all dirt and burrs. Inspect the dowels. If they are loose or show any signs of shearing or burrs, pull them. If a new flywheel is being installed, remove the old dowels, regardless of condition.

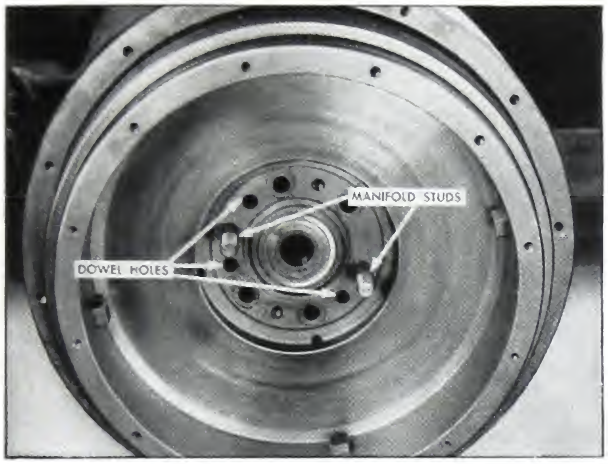


Fig. 12-12. Guiding the flywheel into place

2. Put a new gasket in place on the flange of the crankshaft.

3. Screw two exhaust manifold studs into the crankshaft flange as guides. Assemble the flywheel over the studs and dowels to the crankshaft flange. If dowels have been removed, match dowel holes in flywheel and crankshaft.

4. Insert the proper capscrews. Tighten them alternately, a little at a time, to pull the flywheel up evenly. Continue until all capscrews are tightened to 170-180 foot-pounds.

5. Attach an indicator gauge to the side of the flywheel housing to indicate the bore of the flywheel. The total indicator reading must not be greater than .004.

6. Shift the gauge to indicate the face of the flywheel. Mark with chalk four spots equidistant on the circumference of the flywheel.

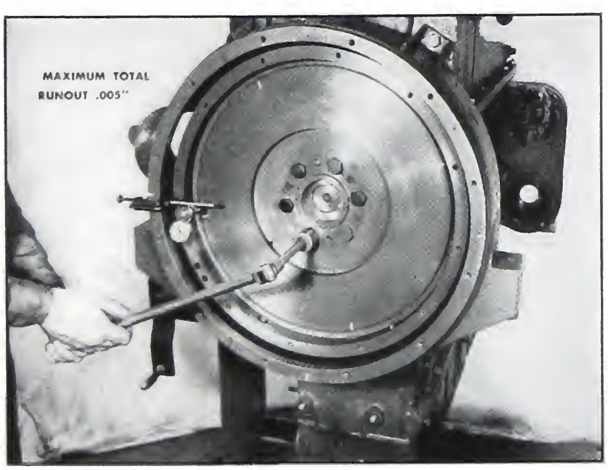


Fig. 12-13. Indicating flywheel face

7. As the crankshaft is turned to bring up each of these chalk marks even with the indicator, take up crankshaft end clearance. With the end clearance taken up, the total indicator reading at these four equidistant points must not exceed .005. If the total indicator reading does exceed .005, remove the flywheel and again clean the faces of flywheel and crankshaft flange. Reinstall and recheck both bore and face.

8. If the old dowels have been removed, use ST-299 to ream the dowel holes in the flywheel and flange to oversize and drive in oversize dowels.

9. Lock the capscrews, in pairs, with lock wires.

Lubricating Oil Pump

1. Using a new gasket, install the lubricating oil pump to the rear face of the timing gear case, meshing the drive gear carefully to the camshaft gear and tightening the four nuts securely. It will be necessary to start the lower inside nut before assembling the pump securely.

2. Prime the oil pump by filling with clean SAE No. 10 lubricating oil through one of the oil line connections in the pump.

NOTE: The scavenger or triple lubricating oil pump, used on engines adapted to severe angle operation, is installed in the same manner as above pump.

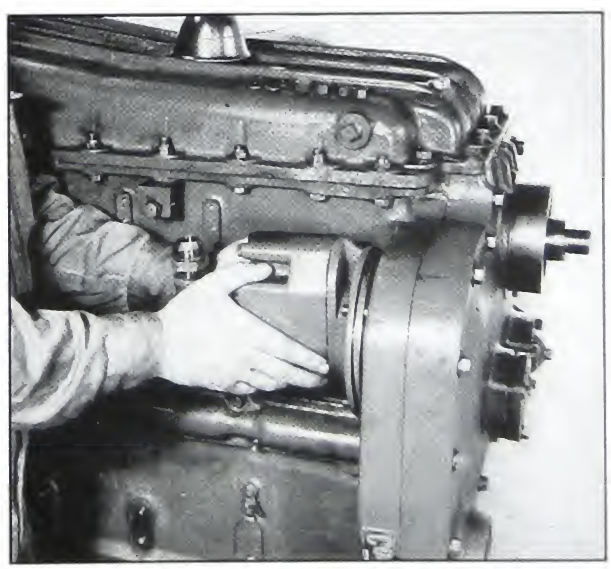


Fig. 12-14. Lubricating oil pump

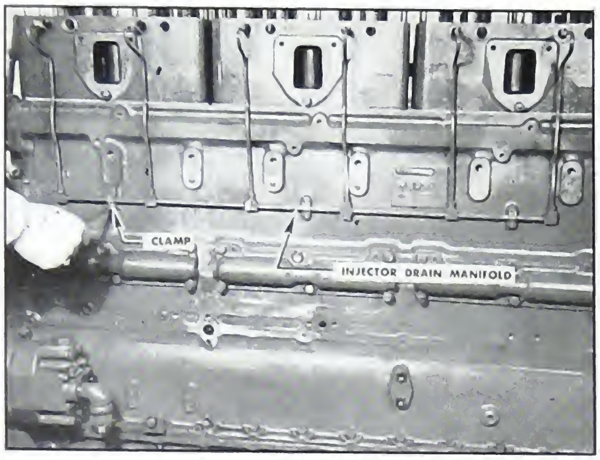


Fig. 12-15. Injector drain manifold

Injector Drain Manifold

1. The injector drain manifold is provided to drain the fuel which has by-passed the injector plunger and carry it back to the fuel pump. This fuel is allowed to by-pass to lubricate the injector plunger.

2. Assemble the injector drain manifold to the cylinder block and secure it in place with small clamps and screws. (Fig. 12-15). Current drain manifolds mount at the compression release shaft outside mounting holes.

Many of the following units vary with engine application or with engine models or series.

Air Compressor
(Model H Series)

Since the fuel pump is driven from the air compressor shaft, the compressor drive gear must be correctly timed. Proceed as follows:

1. Crank the engine one-fourth turn past top center firing position. This will be No. 1-6 V.S., or No. 1-4 V.S., position. In this position, two punch marks will appear on the face of the camshaft gear. Refer to "TIMING MARKS ON CAM GEARS", Page 2-8.

2. Mesh the compressor gear with the camshaft gear by indexing the one punch-marked tooth on the compressor gear (Fig. 12-16) between the two punch-marked teeth on the camshaft gear. (Fig. 12-17).

NOTE: This can be checked through the front of the gear housing (as shown in Fig. 12-18) by

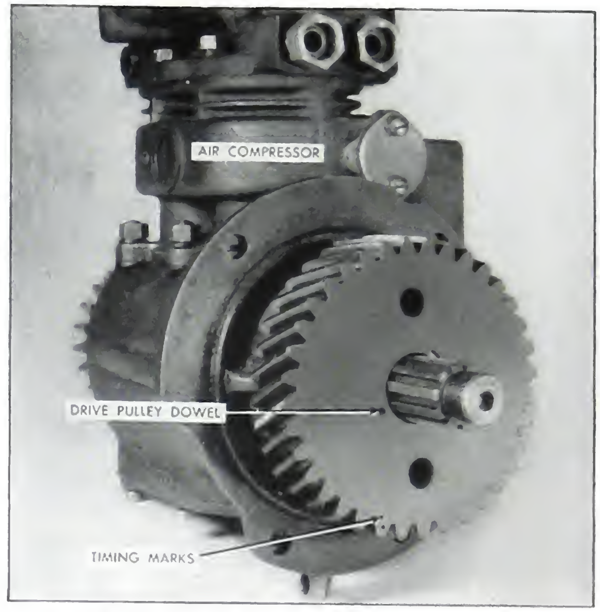


Fig. 12-16. Timing marks on air compressor gear

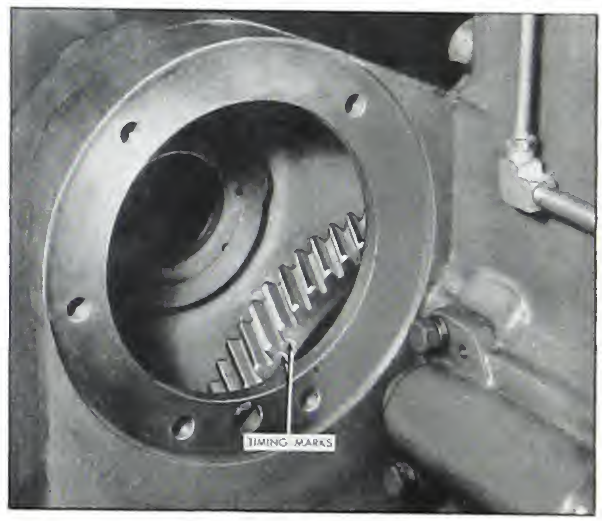


Fig. 12-17. Timing marks on camshaft gear

putting chalk marks on the top of the two teeth on the camshaft gear and a chalk mark on the tooth of the compressor gear marked.

3. Attach the compressor securely to the engine with five lockwashers and capscrews.

NOTE: On some engines the compressor is mounted over the governor or generator, and driven from the end of the crankshaft.

Fuel Pump And Compressor Drive
(NH Series)

1. Bar the engine one-fourth turn past Number 1 Top Center position, to Number 1 Valve

Set position. In this position, the two punch-marked teeth on the cam gear will show through the hole in the gear case. (Fig. 12-17). Refer to "TIMING MARKS ON CAM GEARS", Page 2-8.

2. Install the compressor drive unit to the cylinder block with the center-punch-marked tooth on the drive gear between the two dash-punch-marked teeth on the cam gear.

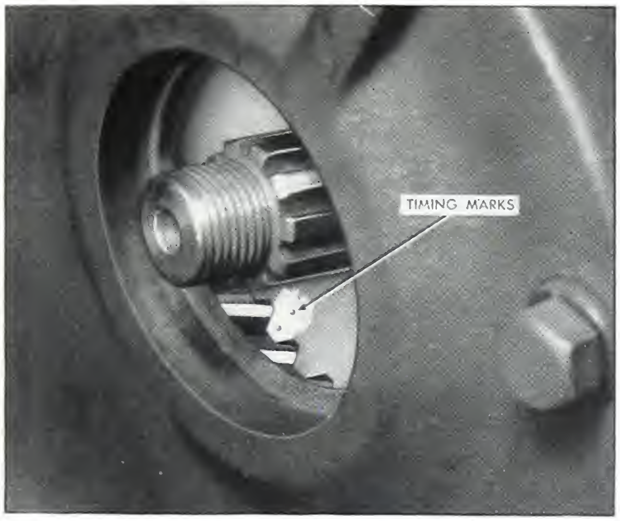


Fig. 12-18. Timing marks through seal hole in gear housing

3. Secure the unit to the cylinder block with capscrews and lockwashers.

Air Compressor
(NH Series)

1. Loosen the adjusting capscrews on the air compressor drive unit and adjust the base to its lowest position.

2. Place the belts over the pulleys on the compressor and drive units.

3. Install the drive unit to the base and secure with lockwashers and capscrews.

4. Tighten the adjusting screw until the air compressor belts have proper tension. Lock in place with lockwashers and capscrews.

TO ALIGN COMPRESSOR DRIVE PULLEY AND COMPRESSOR PULLEY: 1. After the compressor has been assembled to the engine, or at any time after the mounting bolts of the compressor or bracket have been loosened, lay a straight edge (as shown in Fig. 12-19) along the faces of the compressor drive pulley and the compressor pulley. The straight edge should touch the pulleys at four points, A, B, C and D.

2. If the straight edge does not touch points A, B, C and D, loosen the adjusting capscrews and shift the bracket or compressor as needed to obtain proper alignment.

3. Tighten the adjusting capscrews.

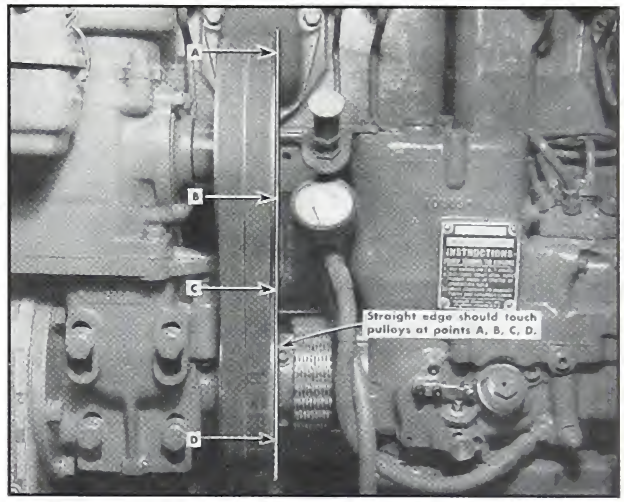


Fig. 12-19. Alignment of pulleys

Water Pump And Fan Drive Pulley

1. Use a high pressure grease on the shaft of the fuel pump and compressor drive and assemble the water pump and fan drive pulley over the keys.

2. Assembly tool, ST-386, screws onto the shaft and pushes the tight fitting pulley over the shaft without danger of breaking the pulley or damaging the bearings.

3. Use a flat washer and locknut or a lock plate and nut to secure the pulley to the shaft.

DD Fuel Pump

As noted in previous instructions, the compressor or fuel-pump-and-compressor-drive must be assembled to the engine at No. 1 Valve Set position regardless of which type fuel pump is to be installed.

The DD fuel pump is assembled and timed to the engine with the crank turned to No. 1 Top Center Firing position. Proceed as follows:

1. Assemble the fuel pump bracket to the cylinder block on the second and third mounting pads from the gear case. The top of the bracket

is secured by capscrews and lockwashers; the bottom of the bracket by a clamp with a center adjusting screw. Assemble the bracket in place, and turn down the center adjusting screw until it holds the bracket snug against the block. Remove the clamp bracket and lock the adjusting screw in position with the lock nut provided.

2. Bar the engine to No. 1 Top Center Firing position. In this position, No. "1-6 T.C." on the fan drive pulley is indexed with the mark on the gear case cover, and both valves are closed for No. 1. cylinder.

3. Remove the peep hole screw which is located to the right of the priming hole. (Both holes are shown in Fig. 12-37). The pump is properly timed when the notch on the distributor disc lines up in the center of the peep hole. Turn the pump until the notch shows, then engage the coupling to the nearest tooth.

4. Assemble the throttle bracket assembly to the cylinder block with a blind gasket to seal off lubricating oil. Assemble the linkage from the throttle bracket to the fuel pump. In idling position, the clamp lever and linkage must be in position to permit full shut-off and full advance of the throttle.

Single-Disc Fuel Pump

All single-disc fuel pumps are assembled and timed to the engine with the crank turned to No. 1 Valve Set position.

LESS-COMPRESSOR-TYPE: 1. Turn the fuel pump drive gear until the timing marks appear in the middle of the inspection hole in the side of the distributor housing. (Fig. 12-20).

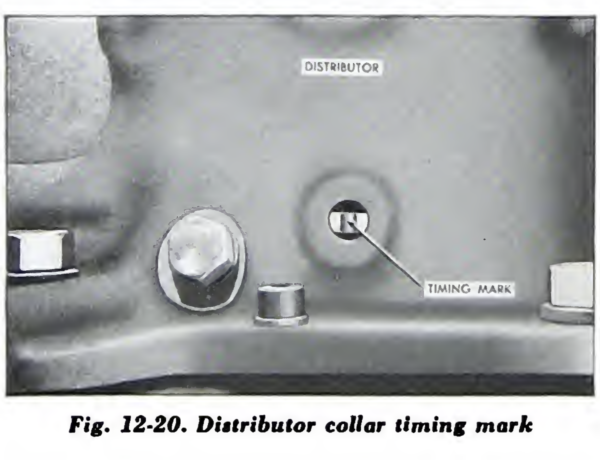


Fig. 12-20. Distributor collar timing mark

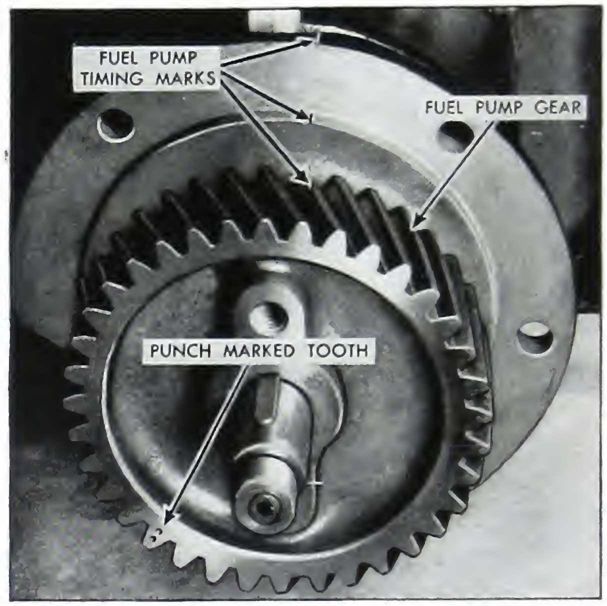


Fig. 12-21. Timing marks on fuel pump

2. Check to see that timing marks on the gear line up with the mark on the governor housing. (Fig. 12-21).

3. Turn the crankshaft one-fourth turn past No. 1 Top Center position to No. 1-6 V.S., or 1-4 V.S. for 4 cylinder engines. At this position, two dash-punch-marked teeth on the cam gear will show through the hole in the gear case. (Fig. 12-16). Refer to "TIMING MARKS ON CAM GEARS", Page 2-8.

4. Install copper asbestos gasket for oil drain hole in pump housing, holding it in place with cup grease.

5. Put chalk on the top of each center-punched tooth on the cam gear and on the marked tooth on the fuel pump gear.

6. Install the fuel pump and gasket to the cylinder block. Index the one center-punch marked tooth on the fuel pump drive gear between the two dash-punch-marked teeth on the cam gear. Check through the inspection hole of the gear case cover to see that the fuel pump gear is properly indexed to the camshaft gear.

7. Install and tighten the capscrews to the governor flange. Install and tighten the two capscrews in the lower mounting flange on the fuel pump housing and the two capscrews on the upper mounting flange of the pump housing.

COMPRESSOR TYPE: 1. Turn the fuel pump

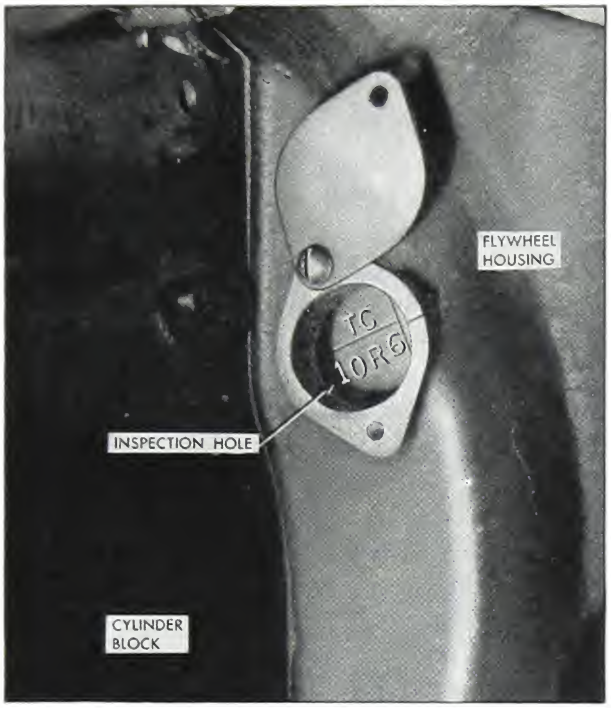


Fig. 12-22. Top center mark on flywheel

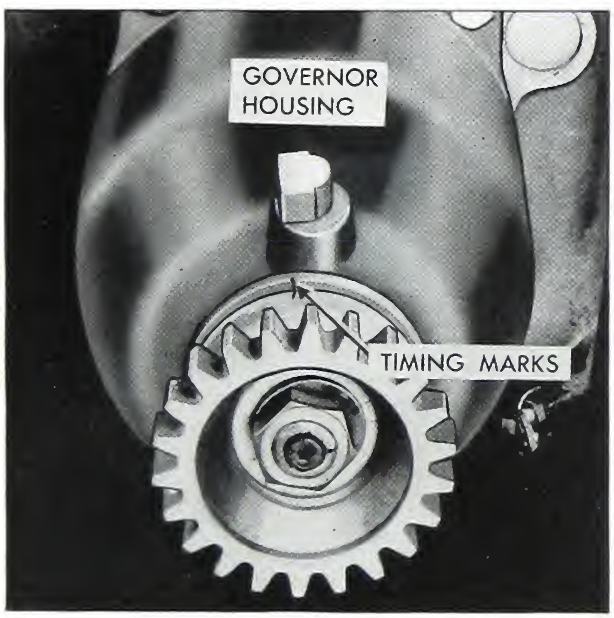


Fig. 12-23. Fuel pump timing mark

coupling spider until the timing mark on the distributor collar lines up with the peep holes in the distributor (Fig. 12-20) and the timing mark on the coupling is in line with the mark on the governor housing. (Fig. 12-23).

2. With compressor, or compressor drive, timed to the engine (SEE ASSEMBLY OF COMPRESSOR AND COMPRESSOR DRIVE) and engine on No. 1 Valve Set position (as in assembly of LESS COMPRESSOR TYPE FUEL PUMP), assemble the compressor-type fuel pump to the engine. Secure with lockwashers and capscrews.

3. Install the coupling chain. It may be necessary to advance the fuel pump coupling sprocket slightly, but this will not affect operation.

Injectors And Connections

1. Insert the push rods for the injector, intake and exhaust valves for each cylinder into the sockets of the cam follower levers. The injector push rod is largest and it goes in the middle socket. The intake valve push rods have collars to match with the milled lift of the compression release. The exhaust push rods are plain.

NOTE: Make sure that there is clearance between injector push rod and compression relief shaft. If several cam follower gaskets have been used to time engines with old camshafts, it may be necessary to grind reliefs on the compression relief shaft nearest the injector push rods.

2. Assemble the crossheads, when used, with the adjusting screws toward the water manifold. Either the crosshead stem or guide must have a relief to prevent hydraulic lock of lubricating oil. If guides do not have the relief and if stems are not drilled, install the grooved, No. 66889-1, crosshead guides.

3. Wrap a rag around a wooden stick and clean the injector seat. The injector sleeves are made of copper and closely machined to seal the injector cup. Never use a screw driver or any metal

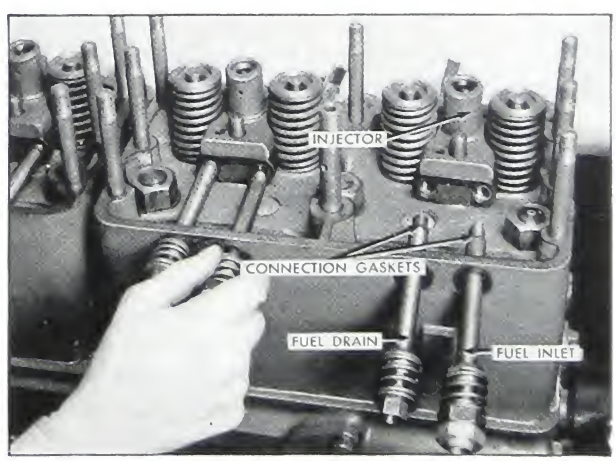


Fig. 12-24. Injector connections

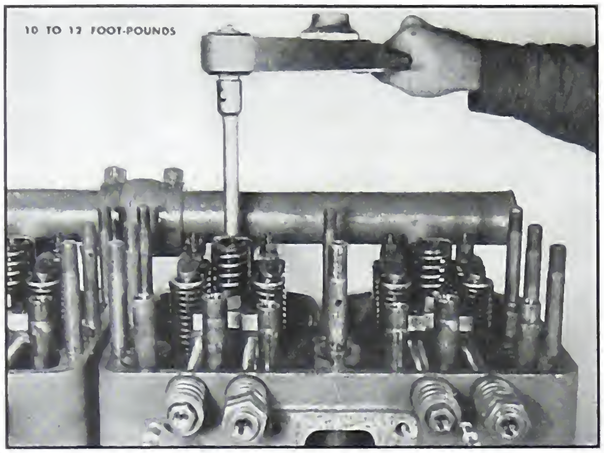


Fig. 12-25. Tightening injector hold down nut

for this operation.

4. Place the injector in its proper position in the cylinder head being very careful not to hit or damage the injector tip.

5. Start but do not tighten the injector hold-down nuts.

6. In order to align the injectors before tightening down the hold-down nuts, screw in the inlet and drain connections about three turns. This is to align the injector body with the fuel connections so that the threaded connecting gaskets will seat squarely against the face of the injector. Always use new gaskets to prevent fuel leaks and dilution of lubricating oil. (Fig. 12-24).

7. With the injector studs well oiled, tighten the injector hold-down nuts to 10 to 12 foot-pounds with a torque wrench. Excessive tightening of these nuts will distort the valve seats and crack the cylinder heads. (Fig. 12-25).

8. Tighten inlet and drain connections to approximately 35 foot-pounds with a torque wrench.

Fuel Supply Lines—DD Pump

1. The fuel supply connection at the top of the distributor nearest the air compressor is the No. 1 outlet. Starting with this connection, fuel fittings, in counter-clockwise rotation, are 1-5-3-6-2-4.

2. For easy assembly and to prevent bending fuel lines, assemble lines in this order; 2 and 4, 1 and 6, and 3 and 5. No. 2 outlet on the DD fuel pump is the one drilled at an angle different from the others. Attach clamps to the fuel supply lines as shown.

3. On the single-disc pump, the connections on the fuel pump distributor are numbered to correspond to the cylinders in firing order.

Rocker Lever Housings

1. Install new rocker housing gaskets over the studs to the cylinder head.

2. Loosen the lock nuts and back the rocker lever adjusting screws off two or three turns. While holding the rocker levers in position, assemble each housing in place with the ball ends of the rocker levers fitting into their respective push rod sockets. Make sure that each oil pipe has two leather seals between the cylinder head and the rocker lever housing. Tighten down the stud nuts.

NOTE: Older-style heads have the counterbore for the leather seals at the bottom of the head and, for these heads, the seals are assembled between cylinder block and head.

3. Place a new gasket on each lubricating oil pipe, and install and tighten down the caps. (Fig. 12-26).

4. Instructions for injector and valve adjustments are given under "Adjustments, Priming and Cold Starting Instructions", this section.

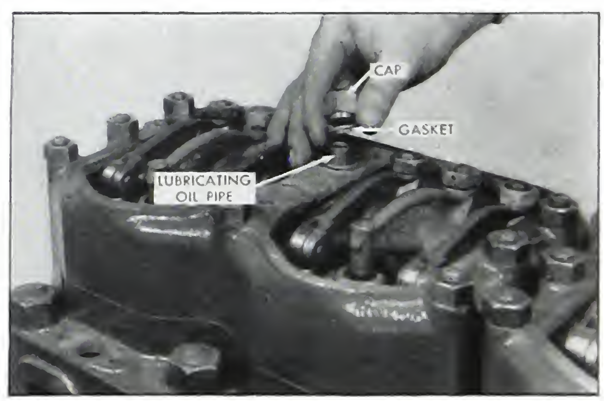


Fig. 12-26. Lubricating oil pipe cap

Setting Compression Release Lever

1. Assemble the fan-hub bracket support and the bell crank, if used, to No. 1 rocker housing. The bell crank is often used to permit operation of the compression release by a cable running to the cab.

2. Crank engine to No. 1 Top Center Firing

position.

3. Turn down adjusting screw of No. 1 intake valve to zero clearance.

4. With a pair of pliers, grip the compression release shaft and turn clockwise until the lift just touches the intake collar of No. 1 push rod. In this position, assemble the compression release shaft lever in the middle of its travel. Tighten clamp screw. Check by moving shaft. Attach the spring to the lever.

CAUTION: TO RELEASE COMPRESSION, IT IS ONLY NECESSARY TO LIFT THE INTAKE VALVES A FEW THOUSANDTHS OF AN INCH. IF INTAKE VALVES ARE OPENED TOO WIDE THEY MAY STRIKE THE PISTONS.

Water Pump And Fan Bracket

1. Place the water pump in position. Assemble the fan bracket over the water pump pulley. Assemble the capscrews to the clamp ring loosely. Turn the water pump to the low point of its eccentric and place the drive belt in position.

2. Insert a large screw driver in the holes provided in the water pump and turn the water pump on its eccentric counter-clockwise to tighten the belt. The belt has proper tension when it can be pushed down about ¾″ with normal thumb pressure.

3. Tighten cap screws in the clamp ring.

4. On engines with high mounted fan, secure the bracket to the rocker housing with capscrews and lockwashers.

Fan Pulley

1. Assemble the belts over the fan pulley and fan drive pulley.

2. Assemble the fan pulley to the water pump bracket.

CAUTION: AVOID STRETCHING THE BELTS. LOOSEN THE ADJUSTING SCREW UNTIL THE BELTS GO INTO POSITION.

3. Tighten the adjusting screw to get proper tension on the drive belts.

4. Make sure dirt exclusion plate is attached to fan pulley.

Generator Drive
(Non-Supercharged Engines)

Use a new gasket. Install the generator drive assembly into the rear of the flange on the cylinder block and secure with capscrews and lockwashers.

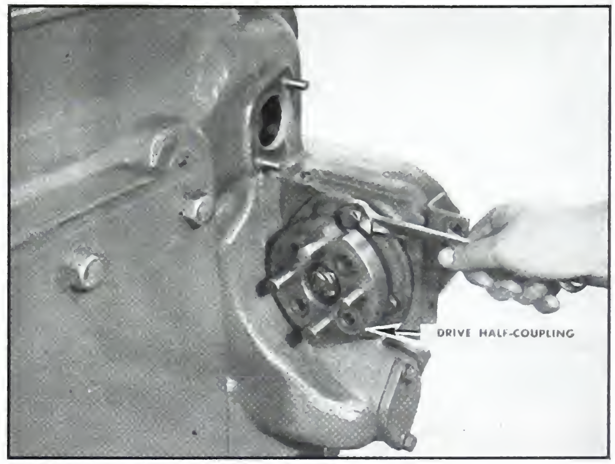


Fig. 12-27. Supercharger drive unit

Supercharger Drive
(Supercharged Engines)

1. Assemble the unit to the gear housing, tapping lightly to insert the shaft through the ball bearing in the gear housing, and secure with four capscrews and lockwashers. (Fig. 12-27).

2. Place the lock ring in the groove in the gear cover end of the shaft. Latest drive shaft has a slotted nut which is secured with a cotter pin.

3. Assemble the cover with a new gasket to the gear housing.

Accessory Drive Pulley

Some engines for special installations have an accessory drive pulley which assembles to the forward end of the supercharger drive shaft. Insert the key in the key way of the shaft and press on the accessory drive pulley. Secure the pulley with castellated nut and cotter pins.

Water Manifold

Assemble the water manifold sections together with hose and clamps. Put heat shields on with the brackets to protect the rubber hose from the heat of the exhaust manifold. Cement a new gasket to each manifold foot and secure the manifold to the cylinder heads. (Fig. 12-28).

NOTE: Some manifold sections are connected by "O" rings and couplings.

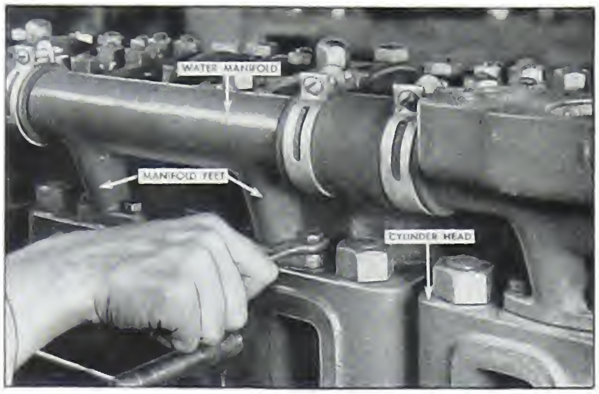


Fig. 12-28. Water manifold

Thermostats And Housings

1. Three thermostats control the temperature of the engine coolant. Two of these are main line thermostats that are mounted in the thermostat housing. The third is a by-pass thermostat that is assembled in the water by-pass connection.

2. Main line thermostats start to open at water temperature of 160° F. to 165° F. and this information is stamped on the flange.

3. The by-pass thermostat closes at 180° F. to 185° F. and this information is stamped on the thermostat flange.

CAUTION: MAIN LINE THERMOSTATS MUST ALWAYS BE OPEN BEFORE THE BY-PASS THERMOSTAT CLOSES TO PREVENT COMPLETE SHUT-OFF OF WATER CIRCULATION AND DAMAGE TO ENGINE.

4. Install the main line thermostats in the housing. It will be necessary to use two gaskets with the new-style, thick-flange thermostats if the counterbore is not as deep as the flange thickness. (This observation also applies to the by-pass thermostat and housing.) Assemble the thermostat housing cover.

5. Install the by-pass thermostat in the by-pass connection. Assemble the connection to the water manifold and cylinder block.

6. Latest thermostats have tangs which match holes in the housing to prevent improper assembly.

Crankshaft Flange And Vibration Damper

Pendulum-type vibration dampers were discontinued in 1947 in favor of a welded construction viscous-type damper. Wear of pins, weights and bushings decrease the effectiveness of the pendulum-type dampers, and if this style damper is still being used it should be replaced with a viscous-type damper.

The new viscous dampers require no service. Lubricant is sealed in at the factory. The fill hole plug is welded closed at the factory and should never be re-opened. To assemble flange and damper:

1. Coat the tapered end of the crankshaft with high pressure grease. Assemble the flange over the key to the crankshaft taper. Install the lock plate and the lock nut. Tighten lock nut and bend up tangs of lockwasher against the flat hex faces of the nut.

2. Assemble the vibration damper over its flange and secure with lockplates and capscrews.

3. Make sure that there are no dents or cracks or broken welds on the damper housing. The inner ring fits closely to the housing with only .015 clearance between the ring and the housing. Any dent may lock the ring in the housing and make the vibration damper useless. A broken weld or crack would permit the silicon to leak from the housing and also render the damper useless. If any of these conditions are present, the damper should be checked before it is installed.

4. Before installing the lock plates bend each end up slightly so they can be easily bent against the hex faces of the mounting capscrews after assembly.

Suction Flange And Screen

Shellac a new gasket to the oil pan suction plate, and check the suction tube screen to make sure that mounting screws are tight. Install the suction tube plate to the bottom of the oil pan and secure with capscrews and lockwashers. Install the suction flange and tube with a new gasket.

Fuel And Lubricating Oil Filters

1. Assemble fuel filter bracket and filter as provided for engine.

2. Assemble lubricating oil filter brackets and filters as provided for engine.

3. Install new filter elements in both fuel and lubricating oil filter cases.

Air Cleaners

1. Assemble air cleaners to their studs using spacers, if required for the application.

2. Install air pre-cleaners, if provided.

Intake Manifold

Assemble new gaskets over the intake manifold ports and install the intake manifold. Slots instead of holes are used at the bottom mounting to facilitate assembly. The upper right mounting hole is used for the mounting of the Nugent strainer, when used.

CAUTION: KEEP ALL AIR INTAKE AND EXHAUST PORTS TO THE MANIFOLDS AND SUPERCHARGER COVERED WITH PAPER AND MASKING TAPE. NEVER STUFF RAGS INTO PORTS.

Lubricating Oil Lines

1. Assemble the lubricating oil flange to the cylinder block and the lubricating oil line from the flange to the air compressor.

2. Assemble the lube oil suction to the intake flange and to the inner connection of the lube pump. Secure to the cylinder block with bracket and one of the oil pan bolts.

3. Assemble the strainer outlet oil line to the connection on the strainer marked "Out" and to the lubricating oil flange at the oil galley on the block. Also, assemble the support bracket to the line as shown.

4. Assemble the lube oil line at the "INLET" of the strainer and "OUTLET" of the cooler. Secure to the cylinder block with clamps on the block, oil flange, lubricating oil pump, and camshaft end plate.

5. Assemble the lube oil line from the oil pump—discharge side—to the oil cooler. A support bracket on the front of the oil pan holds the two support clamps for this line.

Fuel Lines

1. Assemble the fuel line from the injector drain manifold to the fuel pump.

2. Assemble fuel lines or tubes from the fuel pump to the priming pump.

NOTE: The priming pump may be located in any one of several different positions on the engine. Sometimes it is located in the cab.

3. Assemble the line from the fuel pump to the fuel filter.

4. Make fuel connections to preheater housing when used.

Remove From Engine Stand

1. Mount front and rear supports to engine.

2. Attach the lifting arrangement and remove the capscrews which secure the engine stand to the cylinder block. Lift engine from stand.

3. Replace the water drain plug in the water jacket at the flywheel end of the block.

Supercharger

CAUTION: AT ALL TIMES BEFORE FINAL ASSEMBLY OF THE OUTLET AND INLET ENDS OF THE MANIFOLD TO THE SUPERCHARGER, THE PORTS SHOULD BE KEPT COVERED. MASKING TAPE MAY BE USED. DO NOT STUFF RAGS INTO THE INLET OR OUTLET PORTS AT ANY TIME AS THEY MIGHT BE LEFT THERE ON ASSEMBLY TO THE ENGINE.

1. Assemble the supercharger inlet and outlet connections to the supercharger. Use hug-nuts and flat washers to secure connections in place.

Care must be given to the tightening of the mounting bolts of the supercharger. Extreme tightening will cause distortion in the housing which will cause the rotors to scrape. When installing the supercharger on the engine, the coupling flanges should mate properly. Any misalignment will cause failure of the bearings inside the coupling. These bearings carry the load transmitted by the coupling pins and they cannot withstand the overload caused by misalignment. Latest superchargers and engines have support ledges to hold supercharger in alignment with coupling. On older blocks, the alignment is entirely dependent on dowel-fit capscrews.

2. Lift the supercharger to the engine and engage the coupling.

3. Start the upper left and lower right bolts to support the supercharger.

4. Start and tighten the upper right and lower left support bolts.

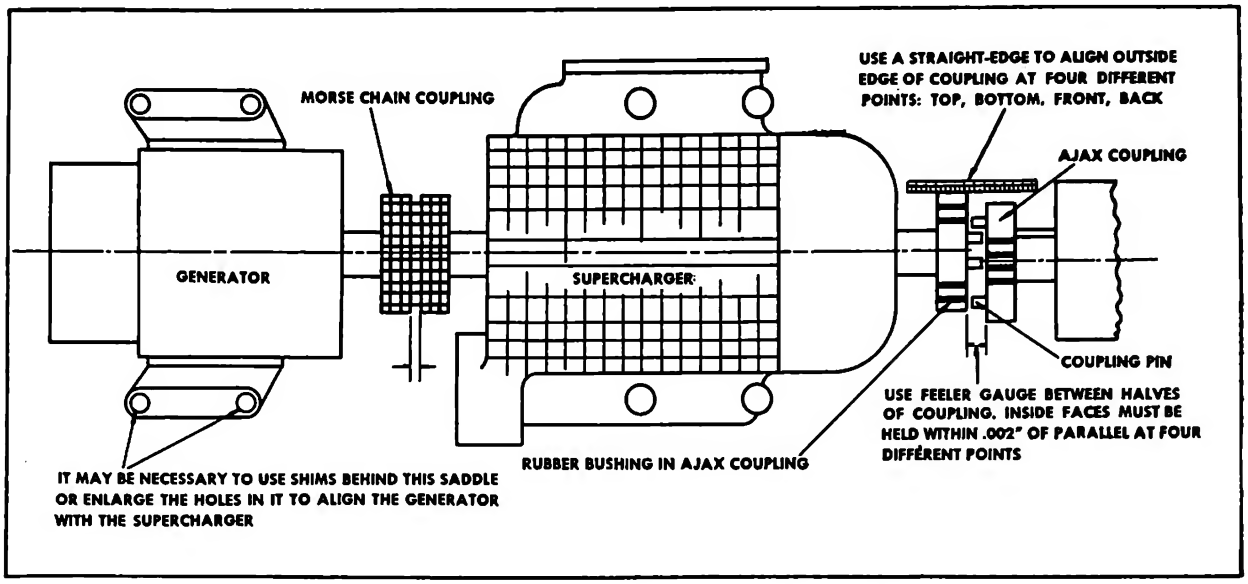


Fig. 12-29. Alignment of generator to supercharger

NOTE: The upper right and lower left bolt holes in the supercharger are reamed holes, and fit the support bolts snugly. A slight coating of oil on the bolts will ease their installation.

5. Tighten the other two support bolts.

6. Check the alignment of the coupling with a feeler gauge between the halves of the coupling. The inside faces of the coupling halves must be held to within .002 of parallel measured at four points—top, bottom and both sides. Check the outside edge at four points. See Fig. 12-29.

7. Once you have the supercharger aligned, do not move it to align with the generator. Instead, move the generator.

8. Replace the coupling chain.

Generator

1. Assemble the generator to the generator bracket. The late style bracket has the word "TOP" cast on the top half of the bracket. If the bracket does not have the word "TOP" cast on it, be sure to mount the generator to the bracket and the bracket to the cylinder block so the two top generator-to-bracket mounting holes are closer to the horizontal center line of the bracket by about one-half inch than the two lower generator-to-bracket mounting holes. Failure to do this will throw the generator lubricating oil cup and oil passages out of position.

2. Mount the generator and bracket assembly to the cylinder block. Make sure generator coupling is properly aligned with drive coupling. Assemble chain over coupling halves.

3. On installations where a center outlet down exhaust manifold is used, some generators require a shield, No. 42527, to protect the rear bearing and commutator of the generator from the heat of the exhaust.

Oil Cooler

1. Put a new gasket over the mounting studs for the oil cooler and start the lubricating oil lines from the supercharger to the oil cooler, and mount the oil cooler to the engine. To tighten the lower mounting stud nut after the supercharger is installed, it will be necessary to use a combination 45° and 90° angle 9/16" end wrench. With the clamps provided, assemble the rubber hose connection to the upper by-pass connection and the oil cooler.

2. The pressure line from the lubricating oil pump is to be connected to the inlet side of the oil cooler. The line to the lubricating oil strainer must be attached to the outlet side of the cooler.

Lubricating Oil By-Pass Valves

1. Engines equipped with an oil cooler have a by-pass valve in the oil cooler cover, or, at the inlet to the block. The by-pass valve must be

properly assembled and used as a protection against a clogged oil cooler.

2. Latest engines also have a by-pass valve built into the lubricating oil pump body to prevent excessively high pressures in the pump, with consequent possible failure.

3. Assemble lubricating oil lines to the block, pan, filter or strainer and cooler as used.

Oil Filler And Gauge Bracket

1. A bracket for the oil filler and oil level gauge, which also acts as an inspection plate, is provided in side of the block or oil pan.

2. Install the bracket with a new gasket and insert the bayonet oil level gauge in the oil gauge tube.

3. Oil pan capacity for all H and NH oil pans is listed on Page 12-24.

Cranking Motor

Assemble the cranking motor to the flywheel housing with its mounting spacer and three lock washers and capscrews.

Exhaust Manifold

1. Assemble the exhaust manifold over the mounting studs. Install the clamps and stud nuts.

2. Exhaust manifolds are available with outlet up or down, and to the rear, center, or front as the installation requires. The hose to the oil cooler must be protected by the heat deflector or shield.

Valve And Injector Adjustments

Make valve and injector adjustments as explained under "ADJUSTMENTS, PRIMING AND COLD STARTING INSTRUCTIONS", this section.

Rocker Housing Covers

1. Install the rocker housing covers to the rocker housings.

2. The cover with the breather cap is generally installed over the oil pan sump.

3. The vapor suction tube from the supercharger air intake connects to one of the housing covers.

Supercharger Connection To Intake Manifold

1. The heat shield is used to prevent intake air from being heated and expanding to cause a loss in horsepower. It is attached to the generator bracket, supercharger outlet connection, and the thermostat housing.

2. While you are installing the heat shield, assemble the supercharger outlet at the top of the supercharger. Secure with eight nuts and lockwashers over the studs.

3. Assemble the supercharger connection to the intake manifold and to the supercharger outlet. Springs are used at the joint to the supercharger outlet to prevent stresses on the supercharger.

NOTE: If the outlet and intake manifold connections are supplied with drilled flanges for capscrews instead of bosses for springs, assemble as follows:

4. Start the capscrews through the holes in the supercharger outlet to the intake manifold connection. Turn them in until the head of the capscrew just touches the machined surface. Do not tighten further. Lock the capscrews with lock wire.

CAUTION: TIGHTENING THESE CAPSCREWS WOULD CAUSE A DANGEROUS STRAIN OF THE CONNECTIONS AND SUPERCHARGER.

HS ENGINES: 1. Install new rubber pack ring in connection.

2. With the air filter in position on the supercharger intake connection, assemble the connection in place and secure with capscrews and lockwashers.

Water Piping

1. Assemble water supply line from the connection at side of the water pump to the air compressor, if used.

2. Assemble the water return line from the air compressor, if used, to the water manifold connection.

3. Make water connections to the oil cooler, if used.

4. On marine units, connect the water manifold to the heat exchanger and oil cooler.

Sylphon Safety Control

1. Engines used in applications where remote control is desirable are often equipped with a Fulton safety control. This control acts to close a valve to shut off fuel supply and ring an alarm when the trip is thrown.

2. Safety trip is thrown by (a) low oil pressure or (b) excessive high temperature of coolant in water manifold. Both controls are adjustable, within specified limits, to application.

3. If safety control is used, make fuel connections between fuel pump and control and run capillary tube to water manifold.

Electric Connections

Make electric connections to mounted equipment, using wire as specified in WIRING DIAGRAMS, Section 10.

Air Connections

1. Connect air vent between supercharger inlet connection and rocker housing cover, after assembly of cover.

2. After installation, make air connections to compressor, brake equipment, etc.

Cold Starting Equipment

See diagrams at the end of Section 10 for installation and wiring of cold starting equipment.

ADJUSTMENTS, PRIMING AND COLD STARTING INSTRUCTIONS

Injector Plunger And Valve Adjustments

Injector plungers and valves should be adjusted before starting the engine the first time, after the first 50 hours service and every 300 operating hours thereafter.

Injector plungers and valves are adjusted on all H and NH series engines 90° after top center firing position and water pump drive pulleys are so marked.

ENGINE FIRING ORDER	
H, HS, NH, NHS, NHRS Six-Cylinder Engines:	
Right Hand	1-5-3-6-2-4
Left Hand	1-4-2-6-3-5
H Four-Cylinder Engines:	
Right Hand	1-2-4-3
Left Hand	1-3-4-2

POSITIONS FOR INJECTOR AND VALVE ADJUSTMENTS: 1. Pull the compression release lever back and block in the open position. This lifts all intake valves and makes it possible to turn the crankshaft without working against compression.

2. Bar the engine in its operating direction to No. 1 top center firing position. In this position both intake and exhaust valves will be closed for No. 1 cylinder.

3. Continue to rotate the crankshaft in its operating direction one-quarter turn and the "1-6V.S." mark for six cylinder (or "1-4V.S." for four cylinder) on the water pump drive pulley will line up with the timing mark on the gear case cover. The engine is now in position to adjust the injector plunger and valves for No. 1 cylinder. (Fig. 12-30).

4. Adjust injector plunger and valve of No. 1 cylinder as directed in succeeding paragraphs under "ADJUSTING INJECTOR PLUNGERS" and "VALVE ADJUSTMENT."

5. Rotate the crankshaft in operating direction to the next "VS" mark corresponding to firing order of the engine. For right hand six-

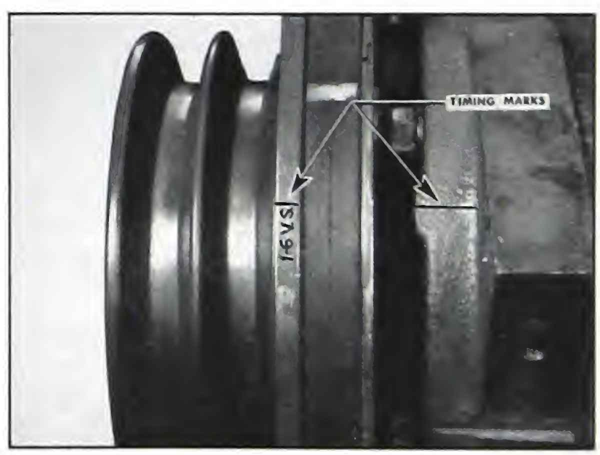


Fig. 12-30. Valve set timing marks

TABLE—INJECTOR ADJUSTMENT

Engine Model	Oil Temp.	Injector Adjusting Screw Torque	Oil Temp.	Injector Adjusting Screw Torque
All H and NH	70° F.	5 ft. lbs.	130-150° F.	6 ft. lbs.

cylinder engines this will be "2-5V.S." and the cylinder ready for adjustment will be No. 5. Consult firing order for other engines.

6. Continue rotation of crankshaft in operating direction and adjustments until all injectors and valves have been correctly adjusted.

CAUTION: TWO COMPLETE REVOLUTIONS OF THE CRANKSHAFT ARE NEEDED TO SET ALL INJECTOR PLUNGERS AND VALVES. INJECTOR AND VALVES CAN BE ADJUSTED FOR ONLY ONE CYLINDER AT ANY ONE SETTING.

Adjusting Injector Plungers

Effective with Engine Serial No. 92096, the injector plungers of all new engines are adjusted with a torque wrench to a definite torque setting. The torque method of adjusting injectors is to be used on all engines after they are retimed as described under the heading "TIMING THE ENGINE", this section.

1. Adjust injector plungers and valves in valve-set position for the cylinder being adjusted as detailed in previous paragraphs under "POSITIONS FOR INJECTOR AND VALVE ADJUSTMENTS". Always adjust injector plunger before valves.

Fig. 12-31. Adjusting injector plunger

2. Check threads of injector adjusting screw and nut to see that they are clean, well-oiled, and free-turning.

3. With engine in valve set position for injector being adjusted, turn the injector adjusting screw down until the plunger contacts the cup, and advance an additional 15 degrees to squeeze oil out of cup.

4. Loosen the adjusting screw one turn.

5. Use a torque screw driver or a small accurately calibrated torque wrench to tighten the adjusting screw to the torque shown in the Table-Injector Adjustment.

NOTES: 1. If a torque wrench is used, it should be equipped with a screw driver adapter and it should read in one-foot-pound divisions. It should have a maximum reading of no more than 15 foot-pounds.

2. Service Tool 68 or any other type of hold-down tool is not to be used when adjusting injector rocker levers by the torque method. To do so would result in a false setting.

3. Template marks and adjusting clips are to be disregarded when using the torque method of injector adjustment.

CAUTION: IN ORDER TO COMPENSATE FOR THE SLIGHTLY RETARDED TIMING EFFECTED BY LOOSER INJECTOR SETTINGS, FIGURES FOR ENGINE TIMING AS DESCRIBED UNDER "TIMING THE ENGINE" MUST BE USED IN CONJUNCTION WITH THE TORQUE METHOD OF SETTING INJECTORS.

Valve Crosshead Adjustment

1. Loosen the valve crosshead adjusting lock nut and back off the adjusting screw one turn.

2. Use light finger pressure at "A" to hold the crosshead in contact with the valve stem "B". Turn down the crosshead adjusting screw until it touches the valve stem "C". (Fig. 12-32).

3. For new crossheads and guides, advance the crosshead adjusting screw 1/3 of one hex (or 20°) more to straighten the stem in its guide and to compensate for slack in threads. On old-

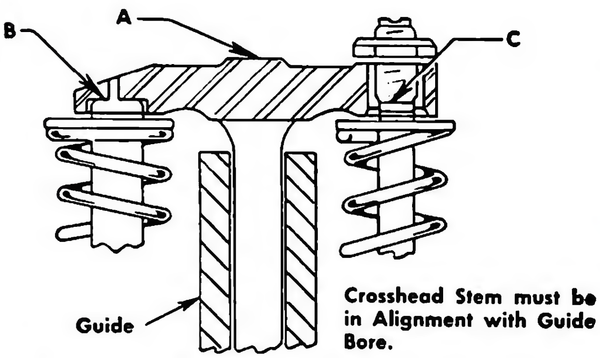


Fig. 12-32. Alignment of crosshead stem and guide

style or worn crossheads and guides it may be necessary to advance the screw as much as 30 degrees in order to straighten the stem in its guide.

4. Lock the adjusting screw in this position. Adjust both intake and exhaust valve crossheads in this manner.

VALVE ADJUSTMENT: 1. The same engine position used in setting the injector is used for setting the intake and exhaust valves.

2. Make sure the compression release is in running position before setting the intake valves.

3. Loosen the valve adjusting lock nut and back off the adjusting screw.

4. With a feeler gauge of proper thickness for the valve being adjusted inserted between the roller and valve stem (or on NH series between crosshead and lever), turn the adjusting screw down until lever or roller just touches the feeler gauge. Lock adjusting screw in this position with the jam nut. (Fig. 12-33).

TABLE—VALVE ADJUSTMENT

(Set with injector plungers adjusted)

Engine	Intake Valves		Exhaust Valve	
	70° F.	140° F.	70° F.	140° F.
H, HR	.016	.014	.024	.022
HS, HRS	.018	.016	.030	.028
NH	.016	.014	.029	.027
NHS	.016	.014	.029	.027
NHRS	.016	.014	.029	.027

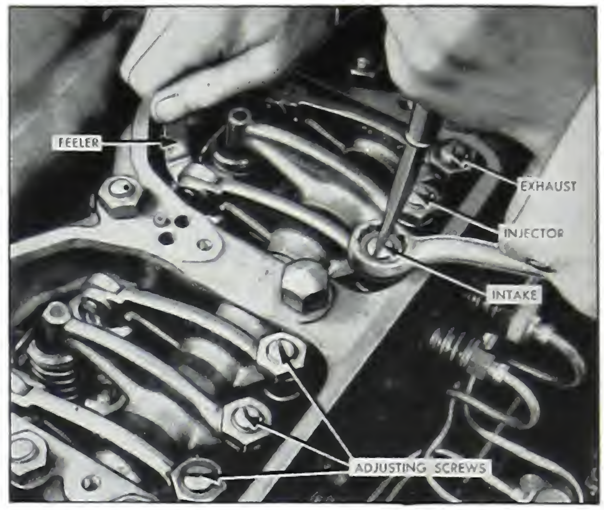


Fig. 12-33. Valve adjustment

5. Always make final valve adjustments after injectors are adjusted, and with the engine warm (oil temperature 140° F.) set valves at clearances as listed in preceding table.

Priming Fuel System

SINGLE DISC FUEL PUMP: 1. Before starting the engine for the first time, or at any time after changing fuel filters or disconnecting fuel lines for any reason, the fuel system must be primed. This is to prevent damage to fuel pump or injector moving parts because of lack of lubrication and to aid in starting the engine.

CAUTION: USE CLEAN FILTERED FUEL OIL TO PRIME FUEL SYSTEM.

2. Remove top cover from fuel filter and fill with fuel. Replace cover.

3. Remove pressure chamber from fuel gear pump and fill housing with fuel oil. Replace pressure chamber.

4. Connect fuel supply tube to a source of clean fuel.

5. Check all lines leading to the engine to detect any leaks.

6. Check the priming pump lines to make sure they are installed properly.

7. Disconnect all injector fuel supply tubes. (Fig. 12-34). Open priming valve approximately two turns. This valve is solely for the purpose of priming, as it by-passes the fuel around the metering pump.

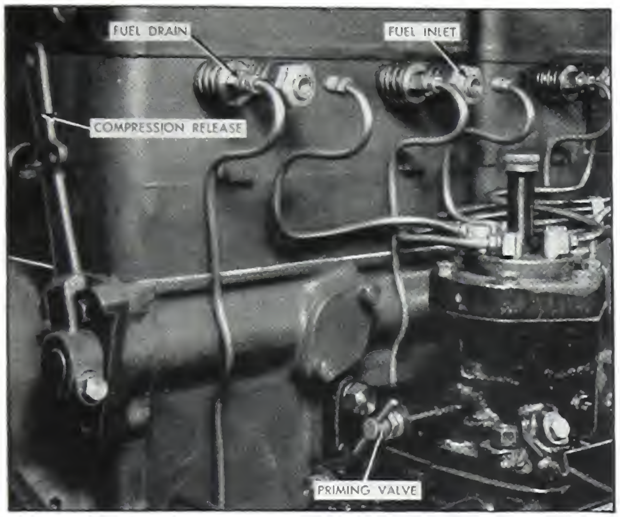


Fig. 12-34. Position for priming engine

8. With a hand crank, rotate the crankshaft until the intake valve on No. 1 cylinder starts to open. Continue to crank the engine in operating direction until the first "PR" mark on the water pump drive pulley comes to the timing mark on the gear cover. Fig. 12-35.

9. Work the priming pump until solid fuel appears at the loosened injector fuel inlet connection.

10. Tighten the fuel line on the cylinder just primed and give the primer one or two more strokes. This pushes the solid fuel to the injector cup to prevent excessive cranking when you are ready to start the engine.

11. Turn the crankshaft in rotating direction until the next "PR" mark on the water pump

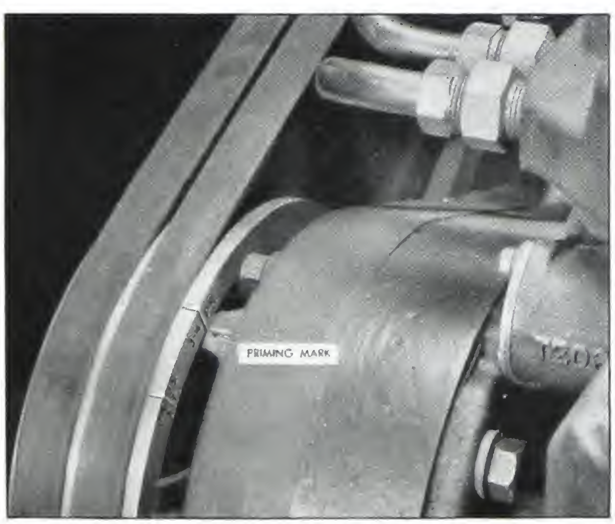


Fig. 12-35. Priming mark

drive pulley indexes with the mark on the gear cover. This brings the cylinder listed next in the firing order to the correct position for priming. Prime this cylinder as previously instructed. It is necessary to prime each cylinder separately. Fuel passages index for only one cylinder at a time.

12. After all injector supply lines are primed and tightened, close the priming valve.

CAUTION: CLOSE PRIMING VALVE BY HAND ONLY. IF VALVE TURNS HARD, LOOSEN PACKING NUT TO PREVENT BREAKING POINT OF VALVE.

13. With the priming valve open, a passage is formed directly from the fuel pressure pump to the injector. Since the fuel is coming directly from the pressure pump to the injector, the governor has absolutely no control over the fuel system. The pressure pump gives the injector an excessive charge of fuel each time the passages in the distributor index to supply fuel to each cylinder. This, in turn, makes the engine run at an excessive speed.

CAUTION: DO NOT ATTEMPT TO RUN THE ENGINE WITH THE PRIMING VALVE OPEN OR SERIOUS DAMAGE WILL RESULT.

DD FUEL PUMP: All fuel passages in the entire fuel system must be full of fuel before starting the engine. "Empty" fuel lines are full of air, and the air must be displaced by priming. Priming will be necessary when the engine is started the first time, after it runs out of fuel or at any time air is allowed to enter the system. Priming also assures initial lubrication to the bearings and bushings. Refer to Figures 12-36, 12-37 and 12-38 for the following operations.

1. Check all fuel lines to avoid possible fuel leaks.

2. Make sure that the emergency shut-off and reset button on the fuel pump is in the open or cocked position. Button should be in "pulled-out" position.

3. Disconnect injector return line at pump.

4. Open priming pump, and pump until solid fuel flows out this opening in the fuel pump. (Fig. 12-36).

5. Replace return line and tighten the connection.

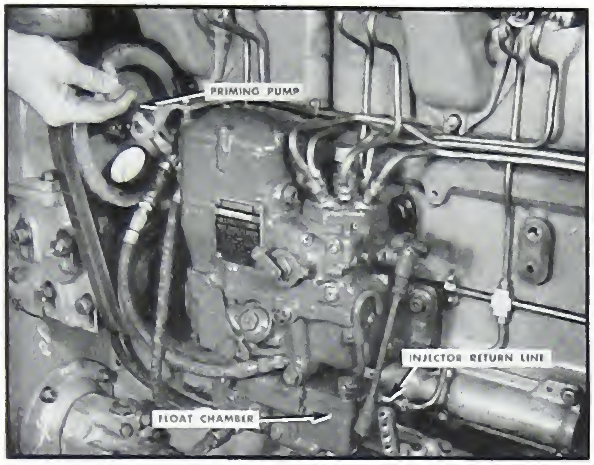


Fig. 12-36. Priming float chamber

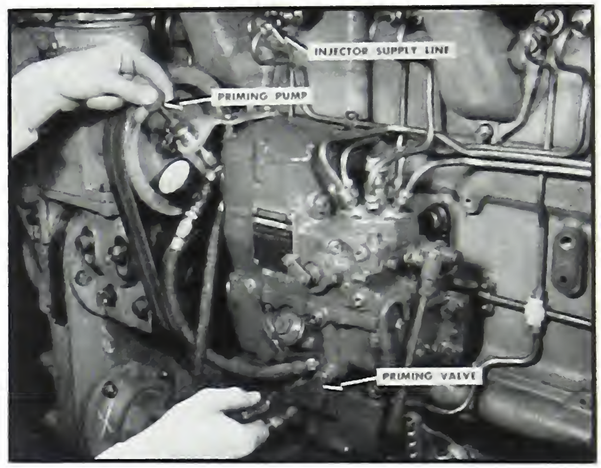


Fig. 12-38. Priming discharge disc and supply lines

6. Loosen injector lines from injector inlet connections.

7. Make sure priming valve is closed. Remove ⅛″ socket head priming plug. Work priming pump until solid fuel comes out of priming plug hole. If fuel does not flow, it is an indication that the suction disc and plate are not indexed, in which case, it will be necessary to bar the engine slightly one way or the other. Prime the suction disc in three of its indexed positions to remove all of the air. Replace the ⅛″ priming plug. (Fig. 12-37).

8. Remove acorn nut and back priming valve one turn off its seat. This valve is provided solely for the purpose of priming the injector lines, as it by-passes the fuel around the suction disc.

NOTE: Latest DD pumps have a retainer nut to lock the priming valve on its seat. It is not necessary to remove this nut; just loosen it until the valve can be backed one turn off its seat.

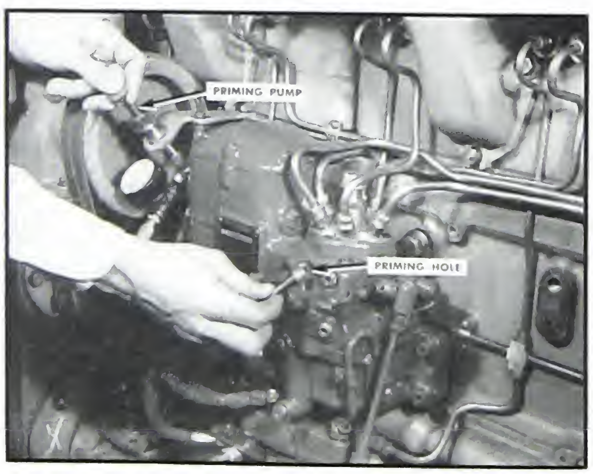


Fig. 12-37. Priming suction disc

9. With a hand crank or other suitable means, bar the engine in operating direction until a "PR" mark on the fan drive pulley is indexed with the timing mark on the gear case cover. Use the compression release for ease in turning. Work the priming pump until fuel comes out of the indexed line, then tighten this line to the injector and give two more strokes of the priming pump. Over priming is not necessary or desirable. Proceed in this manner until all six lines and injectors have been primed. Refer to Fig. 12-38.

10. Close priming valve and replace acorn nut and washer. When a rubber seal washer is used with the acorn nut, the nut should be tightened to 12 ft. lbs.

CAUTION: OVERTIGHTENING ACORN NUT MAY LIFT VALVE OFF ITS SEAT.

NOTE: If the engine has not been properly primed it may overspeed. A small amount of air in the line may cause the engine to run unevenly for a short time; however, if the engine is allowed to continue running it will prime the air out of the lines and settle down to normal operation.

Fill And Prime Lubricating System

PRIME LUBRICATING OIL PASSAGES: 1. Remove one of the Allen set screws from the oil header at the side of the cylinder block and con-

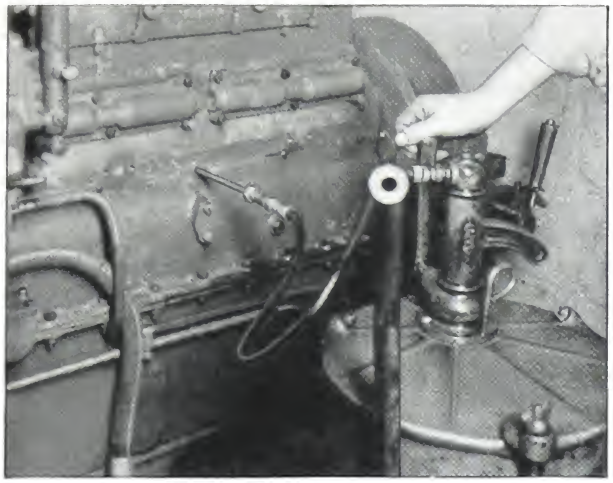


Fig. 12-39. Priming lubricating oil passages

nect with a hand priming pump and source of good, clean SAE No. 20 lubricating oil. (Fig. 12-39).

2. Take care not to operate the engine at higher speeds than recommended on Page 12-38 or oil will by-pass until the temperature rises to operating range.

3. Prime until a 30 psi minimum pressure is reached.

4. Pull the compression release and crank engine for a minimum of 15 seconds with the external oil pressure at a minimum 15 psi.

5. Return compression release to running position; allow engine to fire and operate from 5 to 10 seconds.

6. Remove the external oil supply and return plug to the oil header.

FILL CRANKCASE: Finish filling the crankcase to the "H" (high) mark on the bayonet gauge with SAE No. 20 lubricating oil. See table "OIL PAN CAPACITIES".

NOTE: Without regard to weather conditions, the initial crankcase filling for new or newly rebuilt engines is to be SAE No. 20 lubricating oil.

CAUTION: AFTER ENGINE IS RUN A FEW MINUTES IT WILL BE NECESSARY TO ADD LUBRICATING OIL TO COMPENSATE FOR THAT TAKEN UP BY THE FILTER AND OIL COOLER.

OIL PAN CAPACITIES: 1. The dip stick, or bayonet gauge, furnished with each Cummins oil pan has two markings, "H" and "L". The "H"

TABLE—OIL PAN CAPACITIES

Engine Series	Oil Pan Part No.	Capacity in Gallons "High"	"Low"
H	1192-8	4	1
H	1205-6	3½	1
H	1283 or -A	4	1
H	1284	3½	1
H	1330	2½	1
H	1331	2½	1
H	1345	4	1
H	1470	4	2
H	1474	3½	2
H	1487 (45° Max. Tilt)	3½	1½
H	1487	5	3½
H	*1627	4	2
H	1745-1	4½	3
H	1970	7½	2
H	*1991	4	1
H	*10001	4	1
H	10139	4	2
H	10146	4	1
H	10147 or -A	4	2
H	*10189	5	2½
H	10248	12	3½
H	10315	5	3
H	10462	5	3½
H	10517-A or -B	4	2
H	10556	4	2
H	10686	5	2½
H	10735	3½	1½
H	40872	4	2
H	66221	4	2
H	66392	4	1
HR	10833	5	3
HR	10834	5	3
HR	10922	4	3
NH	10404-2	7	4
NH	10438	7	4
NH	10451	6½	4
NH	10474	7	4
NH	10492	6½	4
NH	10546	6	4
NH	10599	7	3½
NH	10600	7	3½
NH	10609	7	3½

TABLE—OIL PAN CAPACITIES

Engine Series	Oil Pan Part No.	Capacity in Gallons "High"	"Low"
NH	10668	8½	5½
NH	10772	7	4
NH	10774	7	4
NH	10775	6½	4
NH	10776	7	3½
NH	10777	7	3½
NH	10778	7	3½
NH	10779	8½	5½
NH	10811	7	4
NH	10812	7	4
NH	11055	7	3½
NH	11102	7	3½

represents the high level to which oil pans should be filled and *with the lubricating oil filters saturated.* The "L" on the dip stick represents the lowest level at which it is safe to operate the engine. The oil level should be maintained as near the high level as possible at all times.

2. Unfortunately, dip sticks sometimes get lost or changed from one engine to another in service. When this happens, it becomes necessary to know oil pan capacity so the markings on the dip sticks can be checked.

3. The following tabulation of Cummins oil pans shows oil pan capacity at high and low levels. All except the pressed steel pans have the part numbers cast on the pans. The pressed steel pans are indicated by asterisks "*". All pressed steel pans on HB-600 series engines have a "High" capacity of 4 gallons and a "Low" of 1 gallon except pan, H-10189, which has a built-in baffle and is used for angular operation up to 16°. H-1627 pan is used on HBS-600 engines.

CRANKING MOTOR AND GENERATOR: Put several drops of SAE No. 10 or SAE No. 20 lubricating oil in bearing cups of cranking motor and generator.

HYDRAULIC GOVERNOR: I. If fuel pump is equipped with Woodward hydraulic governor, fill the governor sump to a level half way up on the glass inspection window with SAE No. 20 lubricating oil.

2. After the initial filling and run-in period the grade of oil to be used for the governor is to be selected according to operating temperature conditions as indicated below:

SAE No. 30 for temperature 80° F and above.

SAE No. 20 for temperature between 20° F and 80° F.

SAE No. 10 for temperatures below 20° F., except in conditions of extremely low temperatures, when it may be necessary to dilute the No. 10 oil with a sufficient quantity of fuel oil or other special fluid to insure free enough flow of the liquid for satisfactory governor action.

WATER PUMP: 1. The water pump bearings should be lubricated after assembly and each 1000 hours thereafter. For this purpose, lubricating holes are provided.

2. Remove two of the pipe plugs from the lubricating holes. Fill the housing—through one hole—with good, sodium soap base, ball bearing grease until the grease comes out the open hole.

CAUTION: TWO PLUGS MUST BE REMOVED WHILE LUBRICATING THE PUMP TO PREVENT BREAKING THE BEARING SEAL UNLESS WATER PUMP IS EQUIPPED WITH A PRESSURE RELIEF FITTING.

FAN HUB: Remove pipe plug and fill hub with ball bearing grease.

VIBRATION DAMPER: 1. The formed and welded, viscous-type damper is filled at the factory with a special viscous lubricant, and the filler hole is sealed closed. *The screw must not be removed from this damper.*

2. Inspect the damper for dents and broken or cracked welds which would render the damper useless. Dents will lock the inside ring and the damaged welds would permit the viscous fluid to escape.

3. Dampers must be considered as expendible equipment after a reasonable period of service. A good check is to install the damper on the engine and during testing watch for any indication of torsional vibration such as noisy gear trains, flapping belts, etc. If trouble is indicated replace the damper and again test to see that it disappears, if not other engine parts should be checked.

Fill Cooling System

WATER TESTING AND TREATMENT: While water is the best coolant for use in an engine it sometimes contains impurities which contribute to corrosion, or others which build up as deposits and interfere with heat transference.

Corrosion or pitting in the water jacket area can be caused by chlorides, sulphates or acids. The presence of these impurities can be detected by any water testing laboratory, and after the type of impurity is known the proper treatment can be recommended to make the water suitable for use in the cooling system. Unfortunately, there is no single water treatment which will correct all undesirable conditions. The test is necessary before the proper treatment can be recommended.

In some localities the water supply is acid, or in other words it has a pH value (hydrogen ion concentration) below 7.0. This type of water must be treated to make it neutral (pH $=$ 7.0) or slightly alkaline (pH above 7.0); otherwise it will cause corrosion. There are corrosion inhibitors on the market which, according to the suppliers, can be added to any water to bring the pH value above 7.0. Of course these inhibitors will not necessarily be suitable for water with chlorides or sulphates. Again, the laboratory test is desirable.

AERATION: The presence of oxygen in the engine coolant greatly accelerates corrosive action. Aeration or entrainment of oxygen may be caused by clogged water passages — dirty radiator, collapsed hose connections, etc. The cooling system must be kept full and the flow unobstructed.

Soluble oil acts to prevent entrainment of oxygen in the cooling system and in that manner it greatly retards or prevents rust and corrosion in most cases. Where soluble oil is used the mixture should be 3% to 4% soluble oil and 96% to 97% water.

There are some drawbacks to the use of soluble oil: The mixture is unstable and ineffective if the water is acid or salty, and if the water has a high degree of alkalinity soluble oil may cause foaming. Also, soluble oil can not be mixed with some anti-freezes.

ANTI-FREEZES: Anti-freezes should have a higher boiling point than water to avoid loss by evaporation; the preference is for the "permanent-type" anti-freezes with ethylene-glycol base properly compounded with corrosion inhibitor. Manufacturers of these types of anti-freezes which are already inhibited do not recommend the addition of soluble oil or other inhibitors in the coolant.

INHIBITORS MUST BE RENEWED: After a period of service—usually one season or less—the inhibitor loses some of its effectiveness. The effective period will vary with the type of water used and the cleanliness of the cooling system. Always follow the manufacturer's recommendations about renewal.

Cold Starting Equipment

PREHEATER: 1. The principle used for starting Cummins supercharged engines is direct preheating of intake air by burning fuel oil in the intake air stream. Also, in extreme cold climates preheating equipment may be used on non-supercharged engines.

2. Fuel is forced by a hand pump through a nozzle which atomizes the fuel and directs it across a continuous spark, or against a glow plug, into the intake air stream. The spark or glow plug ignites the fuel.

3. Installation diagrams for both types of preheaters are shown at the end of Section 10. Different cold starting procedures are required for the two types of equipment.

COLD STARTING INSTRUCTIONS: PRE-HEATER WITH SPARK COIL AND ELECTRODES: Supercharged Engines:

1. Open the throttle half-way.

2. Prime the pre-heater slowly with the pre-heater priming pump until the spark coil makes a buzzing sound.

3. Press the starter button and continue to pump the pre-heater primer as rapidly as the pressure in the line will permit. A supercharged engine should start within a few seconds. Continue to operate the pre-heater primer until the engine will run without the pre-heater.

4. **Non-supercharged Engines:** As soon as the

engine fires once, or after thirty seconds of cranking and priming, stop the priming operation, and continue to crank the engine with the starter. The engine should start as soon as fuel stops burning in the manifold and additional free air is available for the cylinder. Non-supercharged engines may not start during the priming operation because the burning fuel in the manifold will consume some of the oxygen in the air.

5. *If the engine does not begin firing within one minute* of cranking, the pre-heater may not be operating, and continuous cranking will only run down the batteries. Lack of spark at the electrodes or lack of fuel in the pre-heater are the principle reasons for engine not starting.

6. Check for spark by removing the pipe plug from the pre-heater housing, and pump the pre-heater primer until the spark coil makes a buzzing sound. With the coil sounding, check the electrodes through the inspection hole to determine whether a spark is being obtained. If there is no spark, remove, clean and reset the electrodes to proper gap of 3/32 inch. If a good spark is visible, determine if fuel is being supplied to the nozzle. If not, the nozzle may be clogged.

7. If the spark coil is entirely inactive, i.e., if it does not make a buzzing sound and if there is no spark when fuel is sprayed from the nozzle, that is an indication that the fuel spray nozzle is set to open before the pressure switch closes the circuit, or the coil is burned out. To determine whether the coil is good, run a jumper across the switch terminals. If the coil is all right, it will buzz and the trouble is in the switch. To correct the setting of the fuel spray nozzle so it will open at the right pressure:

A. Disconnect the fuel line from the nozzle adapter and the wires from the pressure switch.

B. Remove the nozzle adapter from the pre-heater housing.

C. Bend back the ear of the lockplate and unscrew and remove the nozzle from the adapter.

D. Re-connect the fuel line and the pressure switch wires. Have a helper operate the hand priming pump while you turn in the adjusting screw very slowly until the fuel flow *stops* just as the spark starts across the electrodes. Turn in the adjusting screw exactly one-half turn more.

E. If coil will not operate after these checks, the switch or coil must be replaced new.

F. Assemble nozzle, adapter, fuel line and wires as removed.

8. When the engine will run without the aid of the pre-heater priming pump, lock the priming pump in closed position, and adjust the throttle to maintain an engine speed of 700 rpm. Allow the engine to warm up slowly. *DO NOT RACE OR LOAD A COLD ENGINE.*

NOTE: It is possible to reduce knocking, common during cold starting, by continuing to prime the pre-heater even after the engine will function without aid of pre-heater. Excessive priming through the pre-heater will cause the engine to surge.

Other Cold Starting Difficulties: *We must remember that not all cold starting difficulties can be overcome with installation of cold starting equipment.*

Fuel with insufficiently low pour point or with poor ignition qualities, weak batteries, clogged filters and fuel lines, leaking valves, worn piston rings, and improper installation of fuel lines are a few other causes of starting difficulties.

COLD STARTING INSTRUCTIONS: PRE-HEATER WITH GLOW PLUG: 1. Set throttle in idle position.

A. With throttle in idle position, sufficient fuel is delivered to injectors to start engine.

B. When the engine starts, the idle governor will control the speed, which is *very important* for good starts. The throttle should remain in idle position as long as it is necessary to use the priming pump.

2. Pump fuel pressure to 40 psi and immediately stop pumping.

A. The dash indicator light should light up when the fuel pressure reaches 30 psi indicating that the pressure switch is all right and that current is flowing to the glow plug.

B. The primer pump and lines will be filled with solid fuel, so that no time is lost when cranking begins.

3. Engage glow plug manual switch and keep it engaged for 20 seconds:

A. This preheats the glow plug to ignition temperature, so that a fire is obtained immedi-

ately after cranking begins. This is very important because cranking without fire merely wastes the battery.

4. Start cranking and, using full strokes of the pump plunger, maintain 80-100 psi fuel pressure throughout each stroke.

5. After engine starts to run, maintain only sufficient fuel pressure to keep the engine idling smoothly. This fuel pressure may vary between 40 and 100 psi.

A. When engine has warmed up until it does not falter between preheater pump strokes, stop pumping and lock pump.

B. When the preheater is not in use, the dash indicator light should be off, indicating that the pressure switch has released and no current is flowing to the glow plug.

DO NOT USE PREHEATER WHEN ENGINE IS PULLING LOAD. THE PREHEATER BURNS INCOMING AIR, AND MAY RESULT IN DAMAGE TO THE ENGINE.

NOTE: If engine gives no indication of starting during the first three full strokes of preheater pump, check intake manifold for heat. If there is no heat, check electric wiring. If wiring is all right, remove 1/8″ pipe plug from manifold near glow plug and check flame by performing Items 2, 3, and 4.

A. If no flame is observed, close glow plug manual switch 15 seconds and observe glow plug through 1/8 inch pipe plug hole. The glow plug should be white hot; if not, connect glow plug to a six volt source and check amperage which should be 30 (minimum). If glow plug is all right, check manual switch and resistor and replace if necessary. The resistor should draw 30 amperes from a six volt source.

B. If dash indicator light is on when manual switch is closed but does not stay on at pressures above 30 psi, the pressure switch is bad and should be replaced.

C. If glow plug is white-hot, and no flame is observed, remove the fuel nozzle and clean.

TESTING THE ENGINE

The "break-in" or "run-in" period for an engine is that initial operating period when moving parts acquire their final finish and mating surfaces reach a full seat. Piston rings must seat or conform to the cylinder liner to control oil and exhaust gases.

An engine can not be broken-in without applying load. Generally speaking, the load should be a *maximum safe* figure. It is not safe to apply full load at the start nor is it safe or desirable to operate at top rpm during the first hour of running.

Engine testing and engine break-in are accomplished at the same time. Engine break-in is necessary for the reasons already given, while engine testing detects possible mistakes in assembly, the need for adjustments as the engine breaks in and the final adjustments for best performance.

Test Equipment

DYNAMOMETER: A dynamometer provides the easiest and most accurate method of applying load to a new or rebuilt engine. Running the engine without load for any extended period is worse than waiting until it is installed and then running it under controlled conditions.

The dynamometer must be equipped with an accurate scale and accurate instruments. A beam-type scale is most reliable.

AIR CLEANER: All engines should be tested with the standard air cleaner approved for the engine model, and it must be hooked up so that the depression does not exceed 10″ of water in the intake manifold taken one inch from the intake opening for standard engines. For supercharged engines, a depression of 12″ of water, taken on the intake side of the supercharger housing at the tapped hole provided therefor, is permissible.

LUBRICATING OIL STRAINER: All engines must be tested with a full-flow lubricating oil strainer (Air-Maze or Nugent) installed to protect against entrapped grit and dirt.

LUBRICATING OIL: 1. Use a good grade SAE No. 20 lubricating oil for engine run-in and until

the first oil change.

2. See Page 12-23 for method of priming oil passages before the engine is started.

Checks During Break-In Run

BLOW-BY GASES: Remove the crankcase breather cap, and on supercharged engines disconnect the suction tube so you can accurately determine the amount of blow-by gases at all times. Blow-by of gases is due to rings not seating. At the end of the break-in run, and under identical load and speed conditions, blow-by should be appreciably less than at the beginning. This is the most important indication of break-in.

If blow-by increases appreciably at any time during the run in, immediately decrease the load and speed. Increased blow-by is the first indication of ring trouble which may cause scoring or seizure of the rings and piston.

After decreasing load and rpm, the blow-by should fall off at once. Run for a few minutes and gradually bring back to load and rpm desired.

KEEP CHECK ON INSTRUMENTS: 1. Oil Pressure Gauge, should indicate uniform pressure during the run. If pressure falls off at any time, shut down the engine and correct the cause.

2. Water temperature, with proper cooling facilities, should remain at or near 170° F.

3. Oil temperature gauge, while not commonly used, will warn the Operator of unfavorable clearances or expansion of parts which may lead to piston or bearing seizure.

UNUSUAL NOISES: Shut down engine at once and find the cause.

Procedure For First Five To Six Hour Run

INITIAL STARTING: After the engine is attached to the dynamometer and ready to run, start it and idle at approximately 800 rpm no-load for 5 to 10 minutes. Check oil pressure and water circulation *immediately*, and look for leaks.

FIRST PHASE: One Hour Maximum: 1. Operate the engine at 1200 rpm.

2. Apply dynamometer load so that engine develops 25% of the horsepower it is rated for at 1200 rpm.

Example: For an NH engine this would be 25% of 121 or 30 hp. maximum.

3. If no trouble is experienced, i.e., if blow-by does not increase, this period may be limited to 30 minutes; otherwise, run for one full hour.

4. The first hour of operation should bring the water and oil temperature to within operating rate. At this time, the injectors and valves should be readjusted.

SECOND PHASE: One Hour Maximum: 1. Increase speed to 1600 rpm.

2. Apply additional load to make engine pull 50% of the horsepower it is rated for at 1600 rpm.

3. If blow-by is not excessive during this run, this period can be limited to 30 minutes; otherwise, run for one full hour.

4. Retighten cylinder head stud nuts as outlined on Page 12-2.

THIRD PHASE: One Hour: 1. Continue to operate the engine at 1600 rpm and apply additional load to develop 75% of rated horsepower at that speed.

2. Run one hour at this rpm and load.

3. If blow-by appears to increase, reduce load to Second Phase specifications for 30 minutes. Then return to Third Phase specifications.

FOURTH PHASE: Three Hours: 1. Increase rpm to 1800 rpm and apply load so engine develops 75% of its rated horsepower at that rpm.

2. Run for three hours at this load and rpm.

Intermittent Power Checks

FIRST INTERMITTENT POWER CHECK: 1. After five to six hours of running under the loads previously described, make governed-speed, maximum-power checks not to exceed five minutes continuous operation. A "green" engine will not develop the rated power as shown on our published curves. The maximum power checks referred to in this paragraph, means the maximum horsepower obtainable from the engine at a speed slightly below the *RPM* where the governor starts functioning to reduce fuel delivery. This can be obtained by adding load until the

tachometer shows a slight reduction in rpm.

2. After each five minute power check, return to 1800 rpm no-load for at least one minute, then bring load to 75% of rated horsepower at 1800 rpm for 45 minutes. See Table I.

3. If a satisfactory power check is not obtained during the five-minute period, a second power check may be made *after a rest period of one minute or longer as described in Step No. 2.*

4. During all these runs, check blow-by gases, etc. Blow-by should be considerably less after the six hours of running, *under identical load and speed conditions as existed at beginning of test,* indicating that rings are seating.

SECOND INTERMITTENT POWER CHECK: Duplicate the first intermittent power check, that is, make full-speed, full-power run for five minutes continuously, drop to 1800 rpm with no-load for one minute, and then run for another 45 minutes at 75% of rated horsepower at 1800 rpm.

THIRD POWER CHECK: 1. At the third power check, determine actual fuel consumption at governed rpm with engine pulling 96% to 100% of its rated horsepower. (96% is considered a satisfactory standard for new or rebuilt engines. The 96% is considered satisfactory at this point, because to complete break-in or wear in of all engine parts will take approximately 60 to 75 hours of operation).

2. Fuel consumption can be determined in either of two ways; (1) by a flow-rate meter or (2) by actually weighing on a beam scale the fuel consumed during five minutes of maximum-horse-power, governed-rpm operation.

3. If engine will not deliver at least 96% of its maximum rated horsepower, the trouble lies with the engine or with fuel delivery. Fuel delivery should be increased until the consumption is equal to the maximum consumption figures given in Table 3. If the engine still will not deliver 96% of its rated maximum horsepower, it needs

Table 1: Maximum and Test Horsepower Ratings

Standard Test Conditions: Temperature Not Over 90° F.: Altitude Not Over 1000 Feet

Derate Horsepower: 1% for Each 10° Temperature Rise Above 90° F., 3% for Each 1000 Ft. Altitude Rise Above 1000 Feet

ENGINE MODEL	HORSEPOWER 100% Rated @ RPM	96% @ RPM	25% @ 1200	50% @ 1600	75% @ 1800
H-400	100 @ 1800	96 @ 1800	18	46	75
H-600	150 @ 1800	144 @ 1800	27	69	112
HR-400	110 @ 1800	105 @ 1800	20	51	82
HR-600	165 @ 1800	158 @ 1800	30	75	124
HRBB-600	*175 @ 2000	168 @ 2000	29	73	121
HS-600	200 @ 1800	192 @ 1800	36	94	150
HRS-600	225 @ 1800	215 @ 1800	39	101	169
NH-600	200 @ 2100	192 @ 2100	31	81	134
NHS-600	275 @ 2100	264 @ 2100	40	109	183
NHRS-600	300 @ 2100	288 @ 2100	44	121	201

*HRBB Engines with No. 11136 camshaft are rated at 180 hp at 2000 rpm.

Table 2. Formula to Determine Brake Horsepower

$$\text{BRAKE HORSEPOWER} = \frac{\text{Torque (in Foot-Pounds)} \times \text{RPM}}{5252}$$

Table 3. Fuel Consumption

Standard Test Conditions:	**Temperature Not Over 90° F.: Altitude Not Over 1000 Feet**
Decrease Fuel Rate:	**1% for Each 10° Temperature Rise Above 90° F., 3% for Each 1000 Ft. Altitude Rise Above 1000 Feet**

ENGINE MODEL	Max. HP @ RPM	Fuel Rate for Maximum Horsepower	
		Lbs. Per Hour	Lbs. Per Five Minutes
H-400	100 @ 1800	44-46	3.8
H-600	150 @ 1800	66-68	5.6
HR-400	110 @ 1800	48-50	4.1
HR-600	165 @ 1800	73-75	6.2
HRBB-600	*175 @ 2000	74-76	6.3
HS-600	200 @ 1800	99-101	8.3
HRS-600	225 @ 1800	107-109	9.0
NH-600	200 @ 2100	84-86	7.0
NHS-600	275 @ 2100	125-128	10.6
NHRS-600	300 @ 2100	138-140	11.6

*See Table No. 1.

adjustment or more run-in.

CAUTION: THE DYNAMOMETER SCALE AND INSTRUMENTS MUST BE ACCURATE.

Load Applications — Installed Engine

After the run-in procedure previously described, the engine should not be applied to full horsepower load for a period longer than ten continuous minutes for the first 50 hours of operation.

It should be explained to the Operator that during long hard pulls, in excess of ten continuous minutes, it is best to drop to a lower gear to prevent maximum horsepower demand. This gives new parts a chance to "wear in" without undue stress and strain.

CHECKS DURING RUN-IN TEST: During the period of engine operation the following checks should be made frequently:

Lubricating Oil: 1. Lubricating oil pressure in a newly rebuilt engine at idling speed should be not less than 15 psi. At maximum engine speed the pressure may rise to as much as 55 psi. The pressure gauge should indicate the pressure at the rear camshaft bearing.

2. Lubricating oil pressure should remain at or near a constant figure at constant engine speed and load after normal operating temperature has been reached. Abnormal high pressures may indicate blocked lubricating oil lines. Abnormal low pressures indicate either an insufficient supply of lubricating oil from the pump or increased oil clearances which may be due to bearing failure.

3. Temperature of the lubricating oil should be approximately 200° F. during engine operation.

4. If new elements or bags have been installed in the lubricating oil filters, the engine should be shut off after approximately 30 minutes operation and additional lubricating oil added to the crankcase to bring the oil level to the "H" mark on the bayonet oil gauge. Thereafter, the oil level should be checked every two hours during run-in test. Any appreciable loss of lubricating oil indicates that it is getting into fuel lines and being burned. Any increase in lubricating oil level indicates dilution by fuel oil.

Engine Coolant: 1. After the engine is started add coolant as needed to completely fill the cooling system and replace entrapped air.

2. 170° F. is the ideal water temperature for best engine performance.

3. Do not stop the engine suddenly after a load run. Heat stored in the iron masses will boil the cooling water in the jackets if air and water circulation is immediately stopped while the engine is hot. Allow the engine to idle for a few minutes before shutting down.

Fuel Pressures: The fuel oil pressure at idling speed should not be below 60 psi. At maximum speed the fuel pressure should be within the following limits:

DD Fuel Pump fuel pressure is 120-125 psi on all engines at governed speed.

TABLE—FUEL PRESSURES

Single Disc Fuel Pumps:

Engine	(Max. psi)
H	120-130
HS	135-145
NH	135-145
NHS	155-165

Fuel Lines: Check all fuel lines and fuel connections to see that they are tight and not leaking.

Lubricating Oil Lines: 1. Check all lubricating oil lines and connections to see that the lines on the pressure side of the lubricating oil pump are not leaking oil.

2. Leaks in lubricating oil suction lines are harder to detect than those on the pressure side of the pump. These can generally be detected by testing with oil from an oil can. If the suction lines leak, it may cause foaming of oil in the crankcase and, eventually, bearing failure.

Overspeed Stop: 1. Overspeed stops, when used, are set to trip and shut off fuel supply when the engine exceeds maximum rated speed by approximately 15%. Under certain conditions the overspeed stop may permit enough fuel to pass to operate the engine at idling speed.

2. After determining and correcting the cause of the overspeed stop trip, reset the overspeed stop in running position.

Compression Release Lever: 1. All Cummins engines are equipped with a compression release lever. Pulling this lever lifts the intake valve push rod and opens the intake valves. This relieves compression inside the combustion chamber and the engine will not run.

CAUTION: IF THE COMPRESSION RELEASE LEVER IS INCORRECTLY ADJUSTED, PULLING THE HAND LEVER TO ITS EXTREME OPEN POSITION MAY CAUSE THE PISTONS TO STRIKE THE INTAKE VALVES AND RESULT IN EXTENSIVE DAMAGE.

2. Normally the compression release lever is used only while cranking the engine over before starting or while making injector and valve adjustments.

Dual Governor Adjustments

SETTING SINGLE CASE DUAL GOVERNORS NOS. 10941, 11134 AND 11135; Refer to Fig. 12-40.

1. Disconnect the torque converter governor flexible drive shaft or de-clutch the converter from the engine so that engine governor will have complete control of engine.

2. Adjust governor to fuel pump linkage as follows:

(a) Loosen the clamping screw on the governor terminal shaft lever.

(b) Rotate the terminal shaft in clockwise direction as shown in the lower view of Fig. 12-40 until the servo piston bottoms.

(c) Obtain the "shut-off" position of fuel pump with the control linkage.

(d) Clamp the terminal shaft lever to the shaft while maintaining settings (b) and (c) above.

(e) Check linkage for freedom from binding over full-fuel lever travel.

3. Back out load-limit screw No. 4 to allow full travel of fuel pump lever.

4. Remove inspection cover.

5. Back out anti-shutdown screw No. 7 to prevent interference of lever with pilot valve extension when governor flyweights are out.

6. Make preliminary adjustments of speed droop in both governors:

a. Loosen the speed droop adjusting screw in the engine governor and move the sliding arm to a position about two-thirds of the slot length away from the maximum droop position. This will provide a relatively small speed droop. Tighten the screw.

b. Loosen the speed-droop adjusting screw of the torque converter governor and move it to one-third of the slot length away from the maximum droop position.

Tighten the screw.

7. Pull the governor terminal shaft lever to full-fuel position as felt when fuel control linkage contacts the stop in fuel pump. At this position, screw in the load limit screw No. 4 by hand to contact its stop lever. Lock in place.

8. Hold the engine speed adjusting lever in part-speed position and crank the engine. If the fuel lever does not go to full-fuel position during cranking—preventing starting of engine—turn the output speed adjusting screw No. 3 clockwise just far enough so that the terminal shaft will advance the fuel pump control lever to full-fuel position.

9. Set approximate maximum engine no-load speed by adjusting screw No. 2 while holding engine speed adjusting shaft lever on stop by rotating clockwise referred to lower view. If the speed regulation of the engine governor (speed difference between no-load and full-load) is to be minimized adjust the engine governor speed droop slide to decrease droop. Readjust screw No. 2 if necessary.

10. Set minimum engine speed per the following conditions:

(a) Where engine must shut down through the engine governor, back off screw No. 1 so that engine will shut off when engine speed adjusting shaft is rotated in a counter-clockwise direction.

(b) Where engine has a shut-down device independent of the governor, adjust screw No. 1 to give engine idle speed (usually 515 rpm approximately) while rotating the engine speed adjusting shaft in a counter-clockwise direction. Lock in place.

11. With the engine either idling or stopped, connect the torque converter clutch or connect the flexible drive shaft to the torque converter governor, making sure that engagement is made so that the torque converter drives the governor. This flexible shaft should have no smaller than 10″ radius bends for satisfactory service life.

12. Loosen clamping screw on the torque converter speed selection shaft lever (11135 only). Advance engine speed adjustment shaft to maximum stop while adjusting screw No. 3 to prevent overspeeding of equipment.

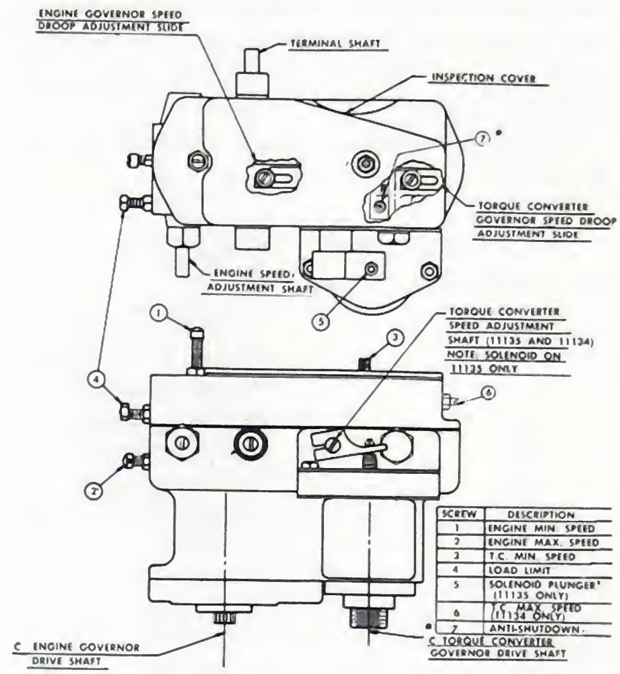


Fig. 12-40. 10941, 11134 and 11135 governor adjusting screws

13. Back out screws No. 3 to approximately engine idle speed.

14. Turn in screw No. 7 until engine speed control is taken away from governor and engine runs at 515 to 700 rpm.

15. Adjust screw No. 3 to obtain specified torque converter full-load speed. See Item 22. (This is torque converter minimum full-load speed setting in 11135 and 11134.)

16. Normally it is desirable to operate with the least amount of torque converter speed droop consistent with the governor stability. With the unit operating as in Item 15, adjust the torque converter speed droop slide (in the direction to decrease droop) to a point beyond which further movement would cause instability. This point will give the fastest action available without being unstable. Readjust screw No. 3 if necessary.

17. With a screw driver, rotate the torque converter speed selection shaft clockwise to obtain torque converter maximum full-load speed. See Item 22.

18. While holding the torque converter governor shaft at the desired speed and with solenoid energized, clamp the lever to the shaft, making

sure the lever is up against the nut on the solenoid plunger shaft. On governor No. 11134 adjust screw No. 6 to contact lever while holding maximum output speed in step 17.

19. Check maximum and minimum torque converter speeds by energizing and de-energizing solenoid.

20. Repeat Items 16 through 18 if necessary.

21. Apply seal to screw No. 2, No. 3 and No. 6 if necessary.

22. If facilities are not readily available for finding the full-load speed position, an approximate torque converter speed setting can be made as follows: Add an assumed speed droop of 150 rpm to the required full-load speed to obtain an estimated no-load speed. This speed can then be adjusted on the unit while unit is running at no load with the master clutch engaged.

SETTING DUAL CASE, DUAL GOVERNORS NO. 10864-1: REFER TO FIGS. 12-41 AND 12-42.

1. Fill the governor sump to the half-way mark on the inspection glass with clean lubricating oil of the same grade as used in the engine.

2. Check to be sure that:
   a. Emergency control valve is OPEN.
   b. Priming valve is CLOSED.
   c. Overspeed stop is in RUNNING POSITION.
   d. All fuel lines are CONNECTED.
   e. Engine is PRIMED.

3. Adjust the adjustable governor-to-fuel pump link to 14¾" length, centerline to centerline of ball joints, and assemble return spring from lever to spring clip.

4. Loosen the clamp screws which hold the governor levers to the terminal shafts of both the engine governor and the auxiliary governor.

5. Back out low-limit adjusting screw in torque converter governor to assure full pilot valve opening for bleed-off. Rotate engine governor speed adjusting shaft to full speed position, and secure temporarily.

6. While holding the fuel linkage by hand, start the engine. Control engine RPM by hand, being careful not to allow overspeeding.

7. With no load on unit, throw in master clutch to engage the torque converter and deck machinery.

8. Use hand fuel control to bring output shaft speed to the minimum no-load output speed required.

9. Use a hand screw driver in the terminal lever shaft to rotate clockwise until the servo piston is at the cut off point.

NOTE: This will be felt as a definite stop when using the screw driver. See Fig. 12-41.

10. While maintaining the settings in steps 8 and 9, clamp the lever on the engine governor terminal shaft.

11. Remove both governor covers and place crosshead in auxiliary governor parallel with the crosshead in the engine governor, and clamp the lever on the auxiliary governor terminal shaft.

12. Disengage master clutch.

13. Adjust engine governor droop slider to mid-position.

14. A. If master clutch is located between the engine and torque converter, adjust by this method:
   a. Adjust the high-limit adjusting screw of the engine governor until the desired maximum governed no-load speed is obtained.

NOTE: To obtain full unit output it is essential that this engine full-load speed be adjusted above that required by the torque converter. The no-load engine speed will be about 100 rpm above the full-load speed when making this adjustment.
   b. If engine is unstable, re-adjust droop slider toward maximum.

14. B. If master clutch is located after the torque converter, adjust by this method:
   a. Engage master clutch and, by engaging machinery clutches and applying sufficient load, stall the output shaft.
   b. Rotate engine speed control lever to contact high-limit screw.
   c. Adjust the engine governor high-limit screw to the point at which the fuel control lever is at maximum-fuel position. This is felt as being a solid stop.
   d. Remove load.

NOTE: Do not keep full-load for more than 30 seconds at one time or torque converter will overheat.
   e. Disengage master clutch.
   f. Go to Step No. 16.

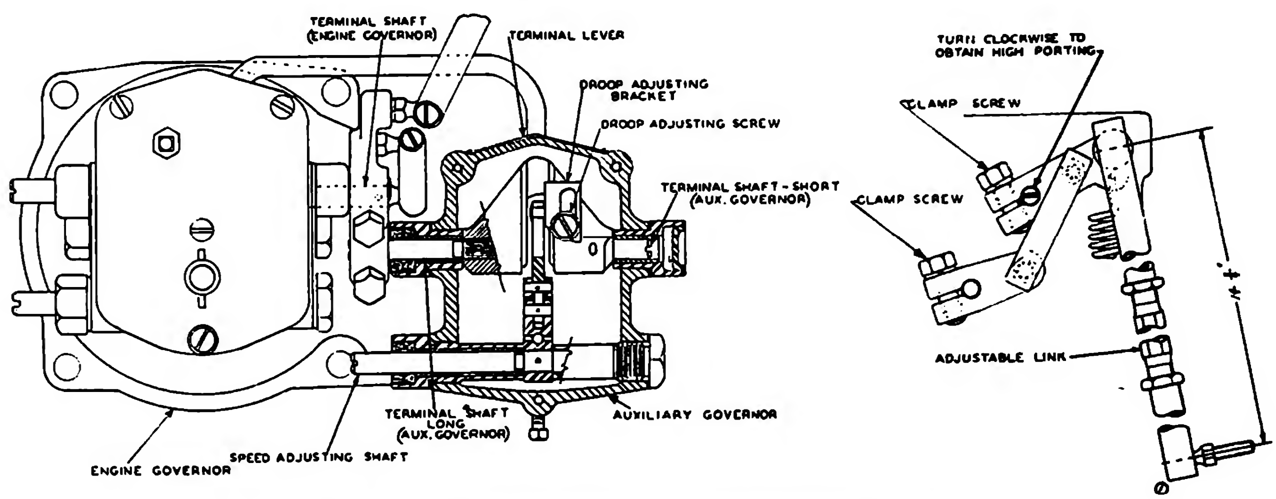


Fig. 12-41. Top view and linkage of dual governor No. 10864-1

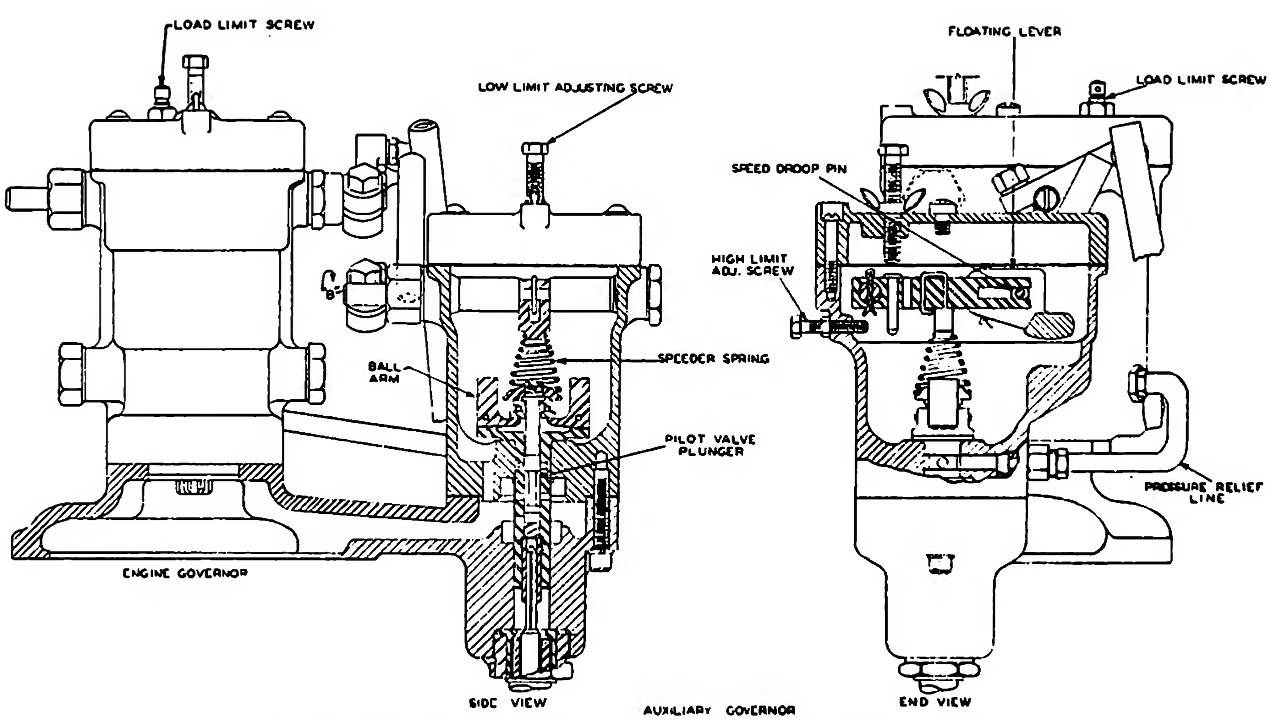


Fig. 12-42. Side view and end view of dual governor No. 10864-1

15. Re-engage master clutch.

16. In the auxiliary governor, adjust the droop slider outward to within about 1/8 inch of its extreme position. (This is near maximum-droop position.)

17. Rotate engine governor speed control lever against high-limit screw. Replace governor top covers.

18. Screw in the low-limit adjusting screw of auxiliary governor until governor just takes over control of unit. There may be instability at this desired minimum no-load speed setting.

19. Adjust the length of the adjustable link to obtain stability. The desired adjustment can be found between the following limits:

a. If link is turned too far in one direction instability will result.
b. If link is turned too far in the other direction, the speed will increase and control will be taken from governor.

NOTE: If less droop is desired, remove auxiliary governor cover and adjust droop slider towards center of governor. Replace cover, and re-adjust per steps 18 and 19 for stability at minimum no-load speed. Usually, it is desirable to operate with the minimum droop that can be obtained with satisfactory stability.

20. Obtain the desired maximum output shaft no-load speed by rotating auxiliary governor speed control shaft and turn in the high-limit screw until it contacts the stop pin. Lock the screw in place.

21. Disengage master clutch.

22. Set engine idle speeds as follows:

a. Where engine must shut down through the engine governor, back out engine governor low-limit adjusting screw so that engine will shut off when engine governor speed control shaft is rotated towards shut-off position.
b. Where engine has a shut-down device independent of the governor, adjust engine governor low-limit screw to give engine idle speed (usually 800 rpm). Lock in position.

23. Loosen the load-limit screw and back off until the terminal lever is moved to full-fuel position. Determine this position by moving the fuel control link upward until fuel pump is in full-fuel position. Set the load limit screw so that it just touches the floating lever, and tighten the wing nut.

NOTE: If instability should possibly occur using cold oil, do not disturb governor settings. Instead, idle the engine on engine governor until warm, or apply load to output shaft until oil is warm. If instability persists after oil is warm, re-adjust, starting with step 19.

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SECTION XIII

UNITS NO. 15 AND NO. 16

Engine Mounting And Adaptations

UNIT No. 15 INSTRUMENT PANELS AND CONTROLS

Because of special requirements and variations in instrument panels and control no attempt will be made in this manual to show panel wiring diagrams or instrument mounting. Special wiring diagrams for power installations are available either from Cummins Engine Co., Inc. or from the contractor or company making the installation.

UNIT No. 16: ENGINE MOUNTING AND ADAPTATION

It is to the mutual advantage of the manufacturer, dealer organization and owners of Cummins engines that all engines be properly installed in their mountings and assembled to their driven units in a manner that will permit the engine to give its best service. This section is devoted to pointing out some of the more common errors in mounting and adaptation and in showing how to avoid those errors.

Front Engine Supports, Flywheels And Flywheel Housings

1. Cummins diesel engines are used in a wide variety of power applications. Literally hundreds of flywheel housings and flywheels are provided for adaptations. Special dealer manuals are provided dealers by Cummins' sales engineering department to help them select the right parts for the application. In case of doubt concerning any application, consult the factory.

2. No attempt should be made to remachine flywheels in a shop that is not equipped to maintain factory standards both as to dimensions and static balance. The static balance tolerance of H and NH flywheels is 2-inch ounces maximum.

Torsionals And Vibration Dampers

TORSIONAL VIBRATIONS: 1. All rotating crankshafts at certain speeds, called critical speeds, become unstable and torsional vibrations are likely to develop. These vibrations, if allowed to continue, will cause excessive wear of gear train driven accessories and will, eventually, cause the crankshaft to break.

2. The diameter and length of the shaft and the load distribution determine, to a large degree, the critical speeds. Therefore, changing the length of crankshaft, by rigidly attaching another shaft of a driven unit to it, will change the critical speed of that crankshaft.

3. If the critical speed occurs in the engine operating range, a vibration damper must be used in that application to prevent crankshaft breakage.

4. Critical speeds are calculated for all standard applications and vibration dampers are specified where needed. Consult with Cummins engineers concerning the need for vibration dampers on any new or different power application.

5. Not all vibration dampers are alike. Most dampers used on H and NH engines are designed to combat, or damp, vibrations of 4½ and 6th orders. The damper must be applicable to the job.

VIBRATION DAMPERS: 1. Either one of two types of vibration dampers may be used on H and NH engines.

2. The damper currently used is a viscous-type damper which consists of a doughnut-shaped ring inside a formed and welded steel housing. Between the ring and housing is a small amount of viscous fluid. Only 1/64" space is provided between the ring and the housing; therefore,

careful periodic inspection is required to make sure that the housing is not dented. A dent may block the ring and render the damper useless. Also with this type damper, occasional inspection must be made to make sure the viscous fluid is not lost because of damage to the housing, broken welds, etc.

3. In the past, vibration dampers with loosely fitted pins and weights have been used on H and NH engines. This type damper required replacement of pins, weights and bushings as these parts became worn. Also, this type damper requires the addition of a special lubricant to maintain a level with the filler hole when the hole is 45° from the bottom center position. The special lubricant consists of a mixture of SAE No. 30 lubricating oil and colloidal graphited oil compound so the total mixture is 2% colloidal graphite by weight.

4. Both type dampers are effective only as long as the weights are free to move within the calculated range.

Marine Gears

ALIGNMENT WITH CRANKSHAFT: 1. The most important precaution to insure satisfactory operation of a marine reverse gear is to make sure that the closest possible alignment is provided between the engine crankshaft and the marine gear. Improper alignment will result in undue wear because of excessive stressing of parts in both the clutch and the reverse gear mechanism.

2. Check the flywheel housing and see that it is the one specified for use with the marine gear.

3. Make sure that flywheel housing and flywheel are assembled as directed in engine assembly section.

ASSEMBLY TO ENGINE: 1. The marine gear and clutch assembly are assembled to the engine as one unit and it is only necessary to remove the small cover plate on the top of the clutch housing for assembly purposes.

2. With the marine gear in place against the flywheel housing of the engine, the bolts which attach the clutch to the flywheel should be assembled first. Care should be taken to pull these bolts up uniformly and to make sure that the pilot on the clutch plate has definitely entered into the flywheel before any of these bolts are pulled up tight and securely locked by means of lockwashers.

3. It is advisable to insert two bolts in the flywheel housing and marine gear case which will serve to guide the pilot in the clutch housing to enter into the flywheel housing while the clutch bolts are being tightened.

MAINTAIN CRANKSHAFT END CLEARANCE: 1. Crankshaft end clearance must be maintained after assembly of gear to the engine. Sometimes long pilot shafts, or tight fitting pilot bearings, tend to reduce crankshaft end clearance. This must be corrected to prevent engine failure.

2. Indicate end clearance with a dial gauge as directed in engine assembly instructions.

ASSEMBLY IN BOAT: 1. Whenever possible, it is recommended that the new marine gear be assembled to the engine before it is installed in the boat.

2. After the entire assembly has been set on the foundation provided for the same, it must be properly aligned with the propeller shaft. Care should be taken to make this alignment without pulling the support brackets on the marine gear out of their proper position, and for this reason it is recommended to provide clearance for shimming at this point. It is advisable to recheck the alignment after the engine foundation bolts have been tightened and then to carefully shim up under the marine gear support bracket.

3. Experience has shown that the hull often changes its shape after the boat has been launched, and it is advisable to recheck and correct the alignment, if necessary, with the boat in the water. This can be accomplished by removing the bolts in the propeller shaft coupling and checking the spacing of the two flanges on the circumference. For satisfactory alignment, the variation should not exceed .004.

Power Generators

1. The same rules given for assembly of marine gears to the engine apply to mounting of power generators.

2. Alignment of armature with crankshaft must be made within close limits.

3. Crankshaft end clearance must be maintained after assembly of generator, or of any driven unit, to the engine.

Intake Air Suctions

1. One essential to get maximum power from the Cummins Diesel is an ample supply of clean air. In addition, it is desirable to be able to control the temperature of that air in regard to outside air temperature. The most desirable temperature for intake air is 60° F. to 90° F.

During hot weather it is recommended that air intake suctions be located outside the hood.

2. The air under the hood is generally extremely hot. In some instances, it runs up to 200° F., as it is heated not only when going through the radiator but also by the hot exhaust manifold. This heat expands the air and causes a reduction in the air weight or the actual amount of air which can be taken into the engine. Thus, when the engine lacks sufficient oxygen, the fuel can not be burned completely, causing loss of power and excess smoke.

3. Under cold weather conditions it may be necessary to provide some means of heating the air to keep it in the desirable temperature range.

Cold air will cause a delay in ignition, irregular combustion and a rough running engine. Also, air cleaner efficiency is lowered because of thickening of the oil in the cleaner cup.

However the air heating arrangement is made, two important points must be remembered: (1) Do not restrict air flow, and (2) Air must always go through the air cleaner.

4. If the engine operates in mountainous country, the oxygen content of air is reduced by altitude. Even though an engine has sufficient air at sea level, it would not have enough when it is most needed, pulling up a mountainside. Generally speaking, an engine loses about 3% of its power for each 1,000 ft. of elevation and 1% for each 5 degrees of temperature increase.

Radiator Shutters

1. The temperature of engine coolant should be kept as near 170° F. as possible for best engine performance. Thermostat controlled radiator shutters, when used in conjunction with main line and by-pass thermostats in the engine, should be set to open about 5° before the by-pass thermostat closes. The shutters should close about 5° after the main line thermostat opens.

2. It is particularly important that the intake air suctions be outside the hood when radiator shutters are used. With the cool air supply cut off by the shutters, the air inside the hood gets heated from the exhaust manifold. Blowers of supercharged engines are not cooled by fan's slip stream and the fan is practically useless.

Fans

1. Sometimes a great deal of power is sacrificed by using oversize fans. In some cases, a fan that is oversize and overspeeded requires up to 16-18 horsepower. Naturally, the power taken for the fan is not available for the truck's propulsion. Large and oversize fans also cause fan belt failures because fan belts are designed for the standard fan only.

2. Generally speaking, the standard fan is quite adequate if you have the correct size radiator and, most important, if the fan is shrouded. Fans should always be shrouded. It is easy to see that there is no economy in wasting 10 hp. on a fan when it can be eliminated merely by using a shroud over the standard fan.

Exhaust Piping And Mufflers

EXHAUST BACK PRESSURE: Exhaust back pressure has become more and more important. If there is any question as to whether this condition is favorable or unfavorable, check it. If the back pressure is too high, you should bring it down to within the ranges given in succeeding paragraphs.

CHECKING BACK PRESSURE: 1. Tap into the side of the exhaust pipe 1½" aft of the outlet flange or manifold and insert a ⅛" Weatherhead fitting. This connection should be flush with inside of pipe and perpendicular with it to avoid impact pressures which would give a false reading. Fasten about 3 feet of copper tubing to the fitting. From the end of the copper tube run a rubber tube to one end of a "U" shaped water or mercury column, commonly known as a manometer.

2. A manometer is not a particularly expensive piece of equipment. If it is absolutely

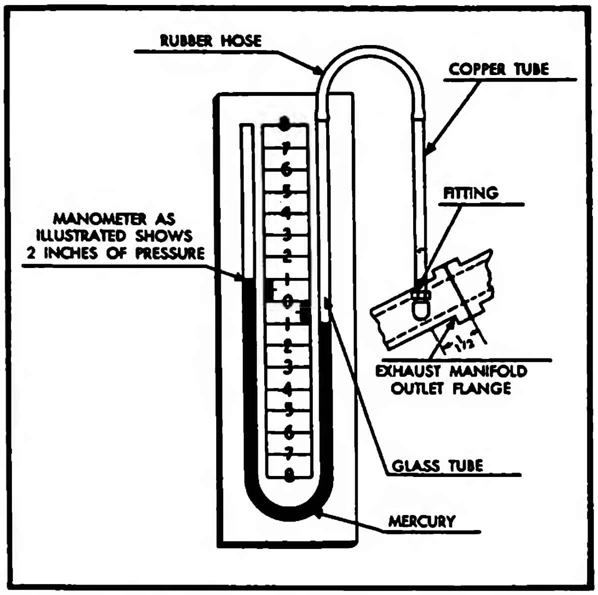

Fig. 13-1. Manometer scale and location on exhaust manifold outlet flange

necessary, you can make one in the following manner: Bend a 4 ft. length of ordinary glass tubing into a "U" shape and fasten it on a board. Mark a scale up to the center of the board between the two sides of the "U". Graduate the scale in tenths of an inch. As you will see in the illustration, the zero mark on the scale is in the approximate center of the columns. The graduations run both up and down from the center zero line. When the manometer is set up for use, enough mercury must be put in the tube so that its height in both columns will line up with the "0" line on the scale.

3. Back pressure readings must be taken when the engine is developing its maximum horsepower and rpm.

4. When you take a reading from the manometer, add the height reading of the liquid in both columns for the final figure. Example: If the liquid is 1.5 inches high in the left column and 1.5 inches low in the right column, you have 3 inches of pressure. If the mercury is 1.5 inches high in the right column and 1.5 inches low in the left column, you have 3 inches of vacuum.

5. A one-inch reading of mercury is equal to .4985 pounds of back pressure per square inch.

6. The back pressure of a standard H and NH engine should not exceed 1 inch of mercury (.50 inches high and low in the two columns) or .49 pounds per square inch. Back pressure of HS and NHS engines should not exceed 1.5 inches of mercury or .735 pounds per square inch.

7. If the back pressure reading on the manometer is too high, you must check the entire exhaust system from the exhaust manifold to the end of the tail pipe. Here are the things which will cause a high back pressure. If one or more of them are present in the engine's exhaust system, they should be eliminated.

a. Right angles (90°) or sharp bends in the exhaust pipe. If it is necessary to bend the exhaust pipe at all, use gentle sweeping curves.

b. Small exhaust pipe diameters. The diameter of pipe throughout the exhaust system must not be smaller than the diameter of the exhaust manifold's outlet flange.

c. Restrictions or stoppages in the muffler device. If there is anything in the muffler which retards an easy passage of the exhaust gas, it should be removed.

d. Small diameter tail pipes aft of the muffler. Beware of this condition as it is a common one.

8. Too much back pressure in a supercharged engine definitely reduces the flushing action of the blower and is extremely detrimental to satisfactory operation.

Water Piping And Oil Coolers

1. Avoid sharp bends in any inlet and outlet water piping and fittings. Sharp bends or pipe

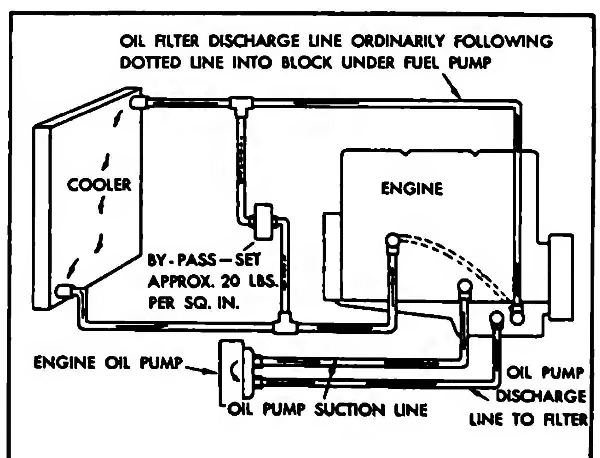

Fig 13-2. Schematic drawing of oil circuit when auxiliary air type oil cooler is used

of insufficient capacity reduces the efficiency of the cooling system.

2. Our experiences with crankcase temperatures have shown that the most desirable lubricating oil temperature for a Cummins Diesel is 180° F.

3. Some installations will require an auxiliary oil cooler to bring the oil heat down to the above figure. Several types of coolers have proved satisfactory, mainly those which use water as the cooling medium and those of the airflow type.

4. If a water type oil cooler is used, you may not be able to get the lubricating oil much cooler than 190° F.

5. The air flow oil cooler, a very coarse tube radiator, mounts in front of the engine radiator. Usually known as the Modine type, it is most frequently found on heavy duty construction tractors. This type of cooler will bring oil temperatures down considerably more than is possible with a water type cooler.

6. When an air flow cooler is used, it is essential that a by-pass valve be set in the feed line. The cooler is connected in series with the oil line between the engine lubricating oil pump and the cylinder block. A by-pass valve must be used so that a full flow of oil through the engine will not be prevented if a low extreme temperature congeals the oil in the cooler.

Fuel Tanks And Piping

1. The fuel tank should have a sump that can be drained easily to eliminate water and other sediment.

2. Generous size fuel lines should be used because of the tendency of fuel to congeal during cold weather.

3. The inlet for the fuel line should be so located that foreign matter will not be picked up.

4. Fuel tank transfer valves located in the fuel line must be of a type which will prevent air being drawn into the fuel line at the stem. Valves must also seat, air tight when closed, otherwise air will be drawn into the fuel from an empty tank.

Gear Ratios And Tire Sizes

A full consideration and discussion of the problems involved in choosing gear ratios and tire sizes can not be undertaken in this manual. However, the following points should always be considered in fitting any engine to a job:

1. Peak horsepower is obtained *only* at maximum governed engine speed.

2. A special study should be made of every truck to determine what gear ratios will give the best over-all performance in the normal operating cycle. The unit would not be efficient if the gear ratios were chosen for only a small portion of the normal run.

3. The more gears there are, the better the over-all performance will be, if the gears are used skillfully. But since the number of gear ratios are of necessity limited, it is important that special attention be given to proper spacing. If some gear ratios are so poorly spaced that they can not be used, they are of no value.

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SECTION XIV

Engine Rebuild Specifications

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	NEW DIMENSIONS Maximum	WORN REPLACEMENT LIMIT

01 Engine Block Group

UNIT NUMBER	PART OR LOCATION	Minimum	Maximum	WORN REPLACEMENT LIMIT
0101	CYLINDER BLOCK			
	Liner Counterbore Depth	.434	.435	.435
	Protrusion of Liner Above Block	.004	.006	.004
	Main Bearing Cap in Block	–.004	–.002	.001
	Main Bearing Bore	4.749	4.750	Same
	Main Bearing Bore—Alignment	Check with ST-136		
	Main Bearing Studs in Block:			
	Tighten to 5¾"/5 21/32" height @ minimum 70 ft. lbs.			
	Camshaft Bushings I.D.	1.9995	2.0025	2.0035
	Cylinder Liners—I.D. "H"	4.876	4.877	4.881
	Cylinder Liners—I.D. "NH" (Chrome)	5.125	5.128	5.131
	Cast Iron Liners—I.D.	5.1245	5.1260	5.130
	Liner to Block Clearance			
	Top Flange	.0015 (Around Entire Liner)		
	Packing Ring Bore	.003 (Around Entire Liner)		
	Bottom of Liner	.010 (Around Entire Liner)		
0102	CRANKSHAFT			
	Main Journals	4.499	4.500	4.497
	Rod Journals	3.124	3.125	3.122
	Fillet Radii	.1725	.1955	Same
	For Other Dimensions	See Crankshaft Dimensions' Chart, P. 2-6		
	Main Bearings—Copper Lead			
	Shell Thickness	.1230	.12375	.1215
	Journal Clearance	.0015	.005	.007
	End Clearance	.007	.013	.022
	Tightening	Template Method		
	.010, .020, .030 and .040 undersize main bearing shells are available.			
	Con. Rod Bearings—Copper Lead			
	Shell Thickness	.07225	.073	.070
	Journal Clearance	.0015	.0045	.007

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	NEW DIMENSIONS Maximum	WORN REPLACEMENT LIMIT
	Tightening	Template Method		
	.010, .020, .030, and .040 undersize connecting rod shells are available.			
0103	CONNECTING ROD			
	Center to Center	11.998	12.000	Same
	Crankpin Bore	3.2722	3.2732	
	Maximum Out-of-round			.002
	Weight Variation in Any one Engine		½ ounce	
	Piston Pin Bushing	2.001	2.0015	2.0025
	Bore Misalignment—Bend	.000	.004 in 12″	.004 on ST-227
	Bore Misalignment—Twist	.000	.010 in 12″	.010 on ST-227
	Bolt Fit in Rod	-.0005	.0005	.0008
	Con. Rod Bolt Min. Diameter	.541	.545	.540
	Side Clearance on Shaft	.006	.011	.015
	Clearance—Rod to Piston Boss	.050		.040 (Min.)
0104	PISTON			
	Ring Groove Clearance	Wedge Type Keystone Rings		
	Piston Skirt Diameter (at 70° F.)			
	20725, 20982	5.1145	5.115	5.1115
	21591	4.8655	4.8660	4.8615
	2770-2	4.871	4.872	4.867
	3719-1	4.869	4.870	4.865
	21740, 21739, 21737, 21582, 21583, 21581, 21584, 21738, 21736	5.1145	5.1150	5.1105
	20737, 20421	5.1195	5.1205	5.1155
	Piston Pin Bore (at 70° F.)			
	Aluminum Pistons	1.9987	1.9989	2.000
	Cast Iron Pistons	1.9994	1.9996	2.0005
	Piston Pin	1.9988	1.9990	1.9978
	Ring Gap Clearances (with new liners)			
	42360	.015	.025	
	41878. 42035	.013	.023	
	42330	.013	.023	
	9236-2, 42331, 65325, 65326	.010	.018	
	60471, 61263, 65354	.010	.020	
	.010, .020, .030 and .040 oversize pistons and rings are available for H and NH engines.			
0105	REAR COVER			
	Cover Plate to Crankshaft Clearance	.004	.006	Use gaskets
	Bore to Crankshaft Clearance	.006	Use ST-162 or ST-287	
0106	CAMSHAFT			
	Injector Lobe Lift	.1325	.1345	.130
	As measured by ST-300	.097	.100	.096
	Journal Diameter	1.997	1.998	1.996

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
0107	**IDLER GEAR**			
	Bushing, No. 9224	1.3745	1.3755	1.377
	Idler Gear Pin	1.372	1.3725	1.371
0108	**GEAR CASE COVER**			
	HS Idler Gear Pin Support to Cover	.010	.012	Same
	HS, NHS Camshaft End Bearing Support To Gear Case Cover	.008	.010	Same

02 Cylinder Heads

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
0201	**CYLINDER HEAD**			
	Valve Springs—Load Req'd. to Compress			
	H, HR, HRS, HRBB Intake and Exhaust—Closed—2 11/16″	110#	122#	105#
	H, HR, HRS, HRBB Intake and Exhaust—Open—2 3/16″	179.5#	198.5#	173#
	NH, NHRS Intake and Exhaust—Closed—2¼″	74#	82#	68#
	NH, NHRS Intake and Exhaust—Open—1 27/32″	104#	114#	95#
	H Intake and Exhaust Valve			
	Seat Angle	30°	30°	30°
	Stem Diameter	.496	.497	.495
	H Valve Guide Bore	.4995	.5005	.5015
	NH Intake and Exhaust Valves			
	Seat Angle	30°	30°	30°
	Stem Diameter	.402	.403	.401
	NH Valve Guide Bore	.4045	.4052	.406
	NH Valve Crosshead Stem Diameter	.3713	.3708	.370
	NH Valve Crosshead Guide	.3755	.376	.378
	H Valve Seat Insert O.D.	2.1275	2.1280	
	.005, .020, .030, .040 oversizes			
	Valve Seat Counterbore	2.1245	2.1255	
	NH Valve Seat Insert O.D.	1.846	1.847	
	.005, .020, .030, .040 oversizes			
	NH Valve Seat Counterbore	1.8435	1.844	
	Cylinder Head Height	5½		
	Injector Seat in Sleeve	60°	60°	60°
	Injector Tip Protrusion Through Head	.040	.055	.065
	Injector Sleeve—Upper I.D.	1.565	1.570	

03 Rocker Levers

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
0301	**ROCKER LEVER HOUSING AND LEVERS**			
	Shaft	1.123	1.1235	1.122

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
	Bushings	1.1245	1.1255	1.1265
	Roller Pin	.3435	.344	.3415
	Roller I.D.	.3445	.3455	.346

04 Cam Follower Levers And Push Rods

0401	CAM FOLLOWER LEVERS AND HOUSING			
	Shaft	.7485	.749	.748
	Bushings	.7495	.7505	.7515
	Rollers O.D.	1.249	1.250	1.247
	Injector Cam Roller I.D.	.503	.504	.505
	Valve Cam Roller I.D.	.5005	.5015	.503
	Levers—Center-to-Center	3.009	3.010	
	Minimum Socket Wall Thickness			.070
	Pins	.4995	.500	.497
	Fuel Push Tube—Ball End Radius	.374	.3745	.500
	Valve Push Tube—Ball End Radius	.312	.3125	.4375
	Note: Worn balls should not be installed in new lever sockets.			

05 Single-Disc Fuel Pumps

0502	FUEL PUMPS			
	Fuel Delivery—CC'S Per 500 Rev. (.020 orifices)			
	H @ 1800 rpm		28	
	HS @ 1800 rpm		41	
	HR @ 1800 rpm		34	
	HRS @ 1800 rpm		41	
	HRBB @ 2000 rpm		31	
	NH @ 2100 rpm		33½	
	NHS @ 2100 rpm		46	
	Head Pressures			
	H	450		450
	HS	550		550
	NH	550		550
	NHS	550		550
	Fuel Pressures			
	At Maximum Governed Speed			
	H psi	120	130	120
	HS psi	135	145	135
	NH psi	135	145	135
	NHS psi	155	165	155
	At Idling Speed H, HS, NH, NHS psi	65		50
	Overspeed Trip		— 15% Overspeed —	
0503	FUEL PUMP HOUSING AND CONTROL LEVER			
	Cam Rocker Lever Bushing (9124-2)	.812	.8125	.8135

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
	Control Shaft Bushing (62351)	.4995	.5005	.5015
	Governor Control Shaft (62350)	.4985	.499	.4975
	Governor Control Rod Bushing (60466)	.6262	.6272	.6285
	Hand Control Eccentric (9120-7)	.5625	.563	.561
	Hand Control Eccentric (9120-7)	.500	.5005	.499
	Center-to-Center Dimensions:			
	Mechanical Governor Link, 4829-4		4	4
	Hydraulic Governor Link, 62309		1⅝	1⅝
	Vertical Lever Link, 9123-7		1⅜	1⅜
	Governor Lever Bushing, 60244	.4995	.500	.501
	Plunger Lever Shaft Bushing, 9144	.749	.7495	.7505
0504	DISTRIBUTOR			
	Drive Shaft	.8105	.811	.810
	Drive Shaft Bushing	.812	.813	.814
	Metering Plunger and Barrel	Select Fit		
	Check Valve Spring, 65506	1.638# @ 1.000″		
	Priming Valve Seat	Check with Prussian Blue		
	Lubricating Check Valve—Open at	85 psi		
	Distributor Disc Bushing to Disc	.003		
0505	CAM ROCKER LEVER			
	Lever (Large End)	.811	.8115	.810
	Lever (Small End)	.623	.624	.622
	Stop Pin Sleeves—See Page 5-39			
0506	VERTICAL LEVER			
	Plunger Lever Shaft, 9118	.7475	.748	.7465
0507	FUEL PUMP MAIN SHAFT AND MECHANICAL GOVERNOR			
	Lift of Cam Lobes—Variance	.000	.002	.002
	Fuel Pump Mainshaft	.9052	.9057	.9042
	Governor Yoke Tube, 9104-5, I.D.	.906	.907	.908
	Governor Yoke Tube, 9104-5, O.D.	1.0575	1.059	1.0565
	Governor Yoke Sleeve, 9103-6, I.D.	1.062	1.063	1.064
	Governor Yoke Bushing, 9728-3 O.D.	1.623	1.6235	1.622
	Governor Housing Bushing, 9114-2	1.625	1.626	1.627
	Governor Control Rod, 9160-1	.6235	.624	.622
	Sleeve Collar, 9110, Center-to-Center	1.7662	1.7692	Same
	Sleeve Collar, 9110, Rod Hole	.4995	.5005	Same
0508	FLOAT CHAMBER			
	Float to Top Plate Clearance	⅛″		
0509	GEAR PUMP			
	Gear Pockets I.D.	1.6028	1.6035	1.6040
	Gears O.D.	1.599	1.5995	1.5985
	Drive and Idler Shaft Bores	.6245	.6255	.6265
	Drive Shaft	.6235	.6238	.623
	Cam Rocker Lever Bushing, 9142-1	.6245	.6255	.6265

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
0510	OVERSPEED STOP			
	Drive Shaft, 62370	.561	.5615	.560
	Shaft Bushing, 62371-S	.562	.563	.564
	Tripping Speed	15% above governed speed		
0511	GOVERNOR DRIVE—HYDRAULIC			
	Lash Governor Spindle Gear to Gov. Drive Gear	.002	.004	Same

05 Double Disc (DD) Fuel Pump

0502	FUEL PUMPS			
	Fuel Delivery—CC's Per 500 Rev. See Page 5-117.			
	Head Pressures			
	All Engines 450 lbs. @ 1000 rpm			
	Fuel Pressures			
	All Engines 120-125 psi			
	Overspeed Trip 15% Overspeed			
0503	FUEL PUMP HOUSING			
	Housing and Control Levers			
	Inner Hand Control			
	Eccentric Bushing	.626	.627	.628
	Outer Hand Control			
	Eccentric Bushing	.4995	.501	.502
	Hand Control Eccentric Pin	.3750	.3753	.374
	Hand Control Eccentric Shaft	.625	.6255	.624
0504	DISTRIBUTOR			
	Metering Plunger and Barrel	Select Fit		
0505	CAM ROCKER LEVER			
	Rocker Lever Bracket Bushings	.8130	.8135	.8145
	Cam Rocker Lever Shaft	.8122	.8125	.8115
	Idle Shut-Down Pivot Pin	.250	.2505	.2485
	Cam Rocker Lever Roller	.750	.751	.748
	Cam Rocker Lever Bushing O.D.	.5065	.5070	.506
	Cam Rocker Lever Bushing I.D.	.3655	.3660	.3665
	Cam Rocker Lever Pin	.3645	.3650	.364
	Stop Sleeves—See Page 5-79			
0506	VERTICAL LEVER			
	Vertical Lever Roller O.D.	.744	.745	.742
	Vertical Lever Pin	.375	.3753	.3747
	Vertical Lever Link Pin	.1875	.1878	.187
0507	FUEL PUMP MAIN SHAFT LIFT OF CAM			
	Lobes Variance. Assembled Position			
	Using ST-356	.000	.001	.002

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	NEW DIMENSIONS Maximum	WORN REPLACEMENT LIMIT
	Mainshaft (Spacing Between Disc Drive Gear and Inner Race of Middle Ball Bearing Using ST-351		4.029	Same
0508	FLOAT CHAMBER			
	Float Valve Travel	.030	.035	Same
0509	GEAR PUMP			
	Gear Pockets I.D.	1.1235	1.124	
	Gear Pockets Depth	.3902	.3907	
	Gears O.D.	1.1229	1.1234	
	Drive Shaft	.3748	.3751	.3743
	Idler Shaft	.3748	.3751	.3743
0511	GOVERNOR			
	Governor Control Shaft	.3750	.3753	.3747
	Governor Thrust Bearing	Check Balls for Flat Spots		
	Governor Sleeve Yoke Roller O.D.	.3730	.3735	.370
	Governor Sleeve Pin	.2495	.250	.246
	Governor Weight Shaft	.3750	.3753	.3745
	Governor Idling Weight Shaft Hole I.D.	.3775	.3785	.3795

06 Injectors And Connections

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	NEW DIMENSIONS Maximum	WORN REPLACEMENT LIMIT
0602	FUEL INLET CONNECTION			
	Check Valve Opening Pressure	45 psi	55 psi	
	Ball Check Valve must not leak at 2000 psi Back Pressure			
0604	INJECTOR			
	Check Valve Spring			
	Free Length			17/64
	Load Req'd to Compress to .193	3.23 oz.	3.93 oz.	3.23 oz.
	Load Req'd to Compress to .154	4.52 oz.	5.52 oz.	4.52 oz.
	Fuel Flow Without Cup @ 200 psi			
	Open Pressure—H and NH	.7 gpm		.7 gpm
	Open Pressure—NHS	1.1 gpm		1.1 gpm
	Check Valve Travel	.015	.025	Same
	Body—Plunger Leakage @ 2000 psi		4 cc	6 cc

07 Lubricating System

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	NEW DIMENSIONS Maximum	WORN REPLACEMENT LIMIT
0701	OIL PAN			
	Capacities (See listing page 12-23)	2½ gal.	12 gal.	

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
0705	OIL COOLER			
	Test Pressure	See Name Plate		
0706	LUBRICATING OIL PUMPS			
0707				
	Shaft, Body End	.8715	.8725	.8705
	Shaft, Bushing Bearing Surface	.8745	.875	.8735
	Bracket Bushing	.876	.8767	.878
	Drive Shaft Bushing	.8745	.875	.876
	Gears, O.D.	2.294	2.295	2.293
	Bodies, Gear Pockets	2.299	2.300	2.301
	Idler Pin, Gear End	.874	.875	.873

08 Cooling System

0803	THERMOSTATS			
	Main Line Thermostat Opens at	160° F.	165° F.	Same
	By-Pass Thermostat Closes at	180° F.	185° F.	Same
0806	SEA WATER PUMP			
	Shaft to Bushing Clearance			.0025
	Gears to Housing Clearance		.005	.020
	Seal Housing Below Spacer Plate	.000	.002	

10 And 11 Intake And Exhaust System

1002	SUPERCHARGER			
	Clearances			
	Rotor to Gear End Plate	.005	.006	.006
	Rotor to Case At Inlet Side	.007		
	Rotor to Case At Outlet Side	.005		
	Rotor to Rotor	.006		
	Rotor Timing Gear Backlash			.004
1003	PREHEATER			
	Electrode Gap	5/64	7/64	7/64

14 Complete Engine Assembly

1401	CAMSHAFT			
	Timing		See Table Page 12-4	
1402	CYLINDER HEADS			
	Tighten Head Stud Nuts			
	Steel Asbestos Gasket	430	450	
	Carrier-Plate Gasket	325	350	

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
	Valve Clearance	**Intake**		**Exhaust**
	H, HR	.014		.022
	HS, HRS	.016		.028
	NH(S), NHRS	.014		.027
1404	**CAM FOLLOWER HOUSINGS AND LEVERS**			
	Timing of Engine	See Chart Page 12-4		
1406	**INJECTORS**			
	Mounting Stud Nuts	10 ft. lbs.	12 ft. lbs.	
	Adjustment	Refer to Page 12-20		
1406	**INLET CONNECTIONS**			
	Tighten to	35 ft. lbs.		
1407	**LUBRICATING OIL PRESSURES**			
	Idling to Governed Speed	5/15 psi	55 psi	
	Normal At Governed Speed	30 psi	50 psi	
1407	**OIL PAN**			
	Bottom of Float to Oil Pan	¾	¾	¾
	Buttress Type Oil Pan	Dowel		
1410	**SUPERCHARGER**			
	Coupling Halves			
	Run-out not to exceed		.002	
1414	**ENGINE HORSE POWER RATINGS**			
	At Maximum Speed Ratings			
	H-6 Cylinder @ 1800 rpm		150 hp	
	HR-6 Cylinder @ 1800 rpm		165 hp	
	HRBB-6 Cylinder @ 2000 rpm		180 hp	
	HS-6 Cylinder @ 1800 rpm		200 hp	
	HRS-6 Cylinder @ 1800 rpm		225 hp	
	NH-6 Cylinder @ 2100 rpm		200 hp	
	NHS-6 Cylinder @ 2100 rpm		275 hp	
	NHRS-6 Cylinder @ 2100 rpm		300 hp	
1416	**EXHAUST BACK PRESSURES**			
	Maximum Permissible—Inches of Mercury			
	H and NH Engines		1.0	
	HS and NHS Engines		1.5	
1416	**FLYWHEEL HOUSING**			
	Bore Run-out	.000	.004	.004
	Face Run-out	.000	.008	.008
	Clutch Pilot Bearing Bore Run-out	.000	.004	.004
	Clutch Drive Ring Pilot Bore	.000	.004	.004
	Clutch Face	.000	.005	.005
	Static Balance Tolerance—Flywheel		2 inch ounces	

Spring Data

PART NUMBER	SPRING	FREE LENGTH	LOAD @	LENGTH
8433-2	Fuel Pump Distributor Disc	2 7/32	396 ± 20#	1½
8521	Injector Connection Check Valve	⅝	11 ± 1 oz.	15/32
9108-2	Governor Maximum Speed	3⅛	411 ± 18½#	2 13/32
			538 ± 27#	2 3/16
9148	Fuel Pump Cam Rocker Lever	2 27/32	70 ± 4#	2.543
			80 ± 4#	2.500
9181	Fuel Pump Plunger	1 17/64	20.4 ± 1#	.863
			23 ± 1¼#	13/16
9207-1	Lubricating Oil Pressure Regulator	2⅝	28.5 ± 1.5#	1⅞
9216-1	Valve	3 37/64	87 ± 4#	2 11/16
			136 ± 7#	2 3/16
9315-1	Injector Fuel Connection	1 1/16	54 ± 4.5#	¾
9337	Injector Plunger Spring	1⅞	64 ± 4#	1 47/64
			142 ± 7#	1 9/16
9367-1	Fuel Pump Vertical Lever		5.8 ± .5#	3/16 deflection
			7.5 ± .5#	7/16 deflection
9460	Fuel Supply Check Valve	13/32	4 ± .3#	5/16
			5.4 ± .5#	9/32
9491-2	Governor Maximum Speed	3	164/182#	2 13/32
			241/267#	2⅛
9492-2	Governor Maximum Speed	3 1/32	265 ± 14#	2 13/32
			387 ± 19#	2⅛
9495-1	Fuel Pump Pressure Regulator	1 9/64	43 ± 2½#	1
			63 ± 3½#	15/16
9520	Governor Maximum	3¼	337 ± 7#	2 13/32
			448 ± 9#	2⅛
9575	Idling	3¼	6 ± 1#	5⅛
			8 ± 1#	6⅛
9589-1	Governor Maximum Speed	3 3/64	102 ± 5#	2 13/32
			147 ± 7#	2⅛
9630	Governor Maximum Speed	2 57/64	124 ± 6#	2 13/32
			196 ± 10	2⅛
9757-2	Fuel By-Pass Valve	1 25/32	.615 ± .0287	1 19/64
9771	Fuel Pump Distributor Disc	2 5/32	521 ± 26#	1½
60414	Governor Idle Speed	1 5/32	27 ± 1.3#	⅞
			52 ± 2.3#	⅝
60692	Distributor Disc	1⅞	410 ± 20#	1⅛
60712	Governor Maximum Speed	3 3/16	74 ± 3½#	2¼
			96 ± 4¾#	2
62079	Governor Maximum Speed	3	28.3 ± 1.4#	2¼
			37.6 ± 1.8#	2
62123	Injector	2 1/32	91 ± 4#	1 47/64
62206	Valve Spring		113 ± 5# Open	
			69 ± 3# Closed	

PART NUMBER	SPRING	FREE LENGTH	LOAD	@ LENGTH
62359	Overspeed Stop Valve	$1\frac{21}{64}$	10 ± .5#	1.3125
62364	Overspeed Stop Reset	$\frac{7}{16}$	4.10# Rate of Deflection	
62373	Overspeed Stop Weight	1.46	1.8 ± .1#	.750
			2.28 ± .11#	.5625
62374	Overspeed Stop Weight	1.294	2.80 ± .14#	.750
			3.77 ± .19#	.5625
62375	Overspeed Stop Weight	1.772	4.96 ± .25#	.750
			5.86 ± .3#	.5625
62411	Injector Check Valve	.289	3.58 ± .35 oz.	.193
			5.02 ± .5 oz.	.154
62860	Governor Maximum Speed	$3\frac{5}{16}$	94 ± $4\frac{1}{2}$#	$2\frac{1}{4}$
			116 ± $5\frac{1}{2}$#	2
62861	Governor Maximum Speed	$3\frac{5}{16}$	167 ± 8#	$2\frac{1}{4}$
			206 ± 10#	2
64851	Governor Maximum Speed	$2\frac{57}{64}$	98 ± 4#	$2\frac{13}{32}$
			154 ± 5#	$2\frac{1}{8}$
65506	Distributor Check Valve	$1\frac{1}{4}$	1.638#	1
66277	Governor Lube Oil Supply Check Valve	$\frac{5}{16}$		
66727-1	Governor Idle Speed	$\frac{51}{64}$	10 ± 1#	$\frac{3}{4}$
			62 ± 4#	$\frac{17}{32}$
66870	Valve	$3\frac{5}{16}$	78 ± 4#	$2\frac{1}{4}$
			109 ± 5#	$1\frac{27}{32}$
67011	Distributor Disc	$2\frac{5}{64}$	625 ± 32#	$1\frac{1}{2}$
67473	Governor Idling Speed	.765/.785	6 ± 2#	$\frac{3}{4}$
			48 ± 22#	$\frac{17}{32}$
67662-1	No. 1 By-pass Valve	$1\frac{31}{64}$	.23 ± .01#	.83
			.35 ± .02#	Per Inch
67675	No. 2 Gear Pump	1.392	13.7 ± 5%	1.209
			74.5 ± 5%	Per Inch
67686-1	Overspeed Stop	1.394/1.294	$9\frac{1}{8}$ ± 1	.844
			12 ± 1	.688
67756-1	Hand Control	$2\frac{5}{16}$	51 ± 2.6#	$1\frac{1}{2}$
			32 ± 1.6#	$1\frac{13}{16}$
67758	Governor Over Run	1.28	82.8 ± 4.1#	Per Inch
			51.4# deflection	
67788	Overspeed Stop Weight	2	1.12 ± .05#	.281
			1.16#	.218
68005-1	Governor Idle	.783	38.2 ± 1.9#	.571
			10 ± .5#	.727
68073	Lubricating Oil By-Pass Valve	$2\frac{53}{64}$	52.2 ± 4#	2
68080-1	Distributor Disc	2.137	310 ± 10#	$1\frac{13}{32}$
68250	Governor High Speed	2.98	76 ± 4#	2.00
68274	Governor Lube Oil By-Pass Valve	3.410	45 ± 3.6#	2.125
			35 ± 2.1#	2.375
68333	Governor High Speed	2.391	69.6 ± 5.5#	1.786
			45 ± 4#	2.00

PART NUMBER	SPRING	FREE LENGTH	LOAD	@ LENGTH
68407	High Speed Governor	2.74	73.4 ± 3.7#	1.786
			57 ± 2.8#	2.00
68451	Overspeed Stop Weight	1.541	.412#	.218
			.392 ± .05#	.281
68651	Overspeed Stop Weight	1.528	.853 ± .05#	.218
			.812 ± .05#	.281
68656	Overspeed Stop Weight	1.208	.646 ± .05#	.218
			.605 ± .05#-	.281
67822	Rocker Lever	1.600	37 ± 1.8#	1.208
			24.7 ± 1.2#	1.338
68997	Valve	3.482	116 ± 6#	$2\frac{11}{16}$
			189 ± 9.5#	$2\frac{3}{16}$
69001	High Speed Governor	2.650	51.8 ± 4#	1.786
			39.0 ± 4#	2.000
69276	Delivery Plunger	.970	18 ± .9#	.770
69353	High Speed Governor	2.600	40.7 ± 5.5#	1.786
			30 ± 4#	2.000
69722	Overspeed Stop	.525	1.02 ± .15#	.218
69724	Overspeed Stop	.533	1.34 ± .20#	.218
69888	Overspeed Stop (Reset)	.941	3.5 ± .20#	.687
69889	Overspeed Stop (Plunger)	.956	1.0 ± .5±	.4375

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